

Report on Nua'ailua Stream Maui, Hawaii



August 2009

State of Hawai'i

Department of Land and Natural Resources

Division of Aquatic Resources

and

Bishop Museum





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Water Resource Management, DLNR
and



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August 2009

Prepared for
Commission on Water Resource Management
Department of Land and Natural Resources
State of Hawai‘i

Prepared by
Division of Aquatic Resources¹
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Section 1: Introduction

Overview

On May 24, 2001, the Native Hawaiian Legal Corporation (NHLC) filed a Petition to Amend the Interim Instream Flow Standard (IIFS) for 27 streams in east Maui on behalf of resident taro farmers. Since the acceptance of the petitions in July 2001, the Commission on Water Resource Management (CWRM) has been focused on gathering information for the 27 petitioned streams. Shortly thereafter, NHLC and CWRM staff reached an agreement that efforts would focus on 8 of the 27 petitioned streams: Honopou, Hanehoi, Huelo, Waiokamilo, Kualani, Pi‘ina‘au, Palauhulu, and Wailua Nui Streams. Currently, the CWRM is collaborating with the State’s Division of Aquatic Resources and the U.S. Geological Survey (USGS) for assistance in collecting biological and hydrologic data to determine measurable interim IFS. CWRM has also requested biological data on the remaining 19 petitioned streams which is the main purpose of this report.

This report is an accounting of the aquatic resources that have been observed in Nua‘ailua Stream, Maui from year 2000 to present. The focus of this report is on the animals and insects that live in the stream and the data collected during surveys. The report covers five main sections, including:

- Introduction
- Watershed Atlas Report
- DAR Point Quadrat Survey Report
- DAR Estuary Survey Report
- Photographs of stream taken during stream surveys

The introduction provides the overview for the purpose of this report, a summary of the findings on the stream and its animals, and a discussion of the importance of the findings and how stream conditions influence native species populations. The Watershed Atlas Report provides a description of the watershed and its aquatic resources from Division of Aquatic Resources (DAR) and other published/unpublished surveys, including a rating of the condition of the stream compared to other streams on Maui as well as statewide. The DAR Point Quadrat Survey Report describes the distribution, habitats, and species observed during the standardized DAR stream surveys. The DAR Estuary Survey Report describes the distribution, habitats, and species observed in the estuary during the standardized DAR estuary surveys. Finally, the photographs provide context to the conditions that the stream surveyors encountered in the stream.

This overview reports on the highlights of these findings and provides a discussion of the importance of the information presented. We hope that this format provides the reader with a simplified, general discussion and understanding of the condition of Nua‘ailua Stream while also providing substantial evidence to support the conclusions presented.

Findings for Nua‘ailua Stream, Maui:

Nua‘ailua is a small (1.6 sq miles), narrow watershed that is steep in the upper sections with little embayment. It is mostly zoned for conservation (97%) with a little agriculture (3%). The land cover is mostly evergreen forest (78%), scrub (15%), grassland (4%) and water (2%). Numerous stream surveys of different types have been completed in Nua‘ailua stream beginning in 1962 to the present. This watershed rates high in comparison to other watersheds in Maui and statewide. It has a total watershed rating of 7 out of 10, a total biological rating of 7 out of 10, and a combined overall rating of 8 out of 10.

Native species observed in the stream include the following categories and species:

Fish - *Awaous guamensis*, *Eleotris sandwicensis*, Gobiid sp., *Kuhlia xenura*, *Lentipes concolor* and *Sicyopterus stimpsoni*

Crustaceans - *Atyoida bisulcata*

Insect – *Anax junius* , *Anax* sp. and *Megalagrion* sp.

Mollusks – *Neritina vespertina* and *Neritina granosa*

Introduced species observed in this stream includes the following categories and species:

Crustaceans - *Macrobrachium lar*

Fish – *Poecilia latipinna*

Insects - *Ischnura ramburi*

Discussion

Nua‘ailua watershed is small, narrow and steep with a little embayment at the stream mouth. The stream flows directly to the ocean through a gravel-cobble beach (Figures 5-6 and 5-7). Stream flow was minimal at the time of the stream survey.

We were able to drive to the mouth and hike to Hāna Highway to survey the lower and middle sections. A helicopter was used to access the upper reaches of Nua‘ailua Stream because of watersheds steepness and inaccessibility by foot.

Estuary surveys were conducted around the stream mouth. Cast net sampling resulted in two endemic fishes; one specimen of **Hawaiian surf fish** (*Iso hawaiiensis*) and one **āholehole** (*Kuhlia xenura*). The physical characteristics of Nua‘ailua estuary were similar to other estuaries surveyed in East Maui, which consisted of boulder terrain, white water and no flow from Nua‘ailua stream into a small coastal embayment.

Point quadat surveys in the lower reach resulted in a variety of native animals. The native goby, ‘o‘opu nākea (*Awaous guamensis*), ‘o‘opu nōpili (*Sicyopterus stimpsoni*), ‘o‘opu ‘akupa (*Eleotris sandwicensis*) were present as adults and juveniles. **Hihīwai** (*Neritina granosa*) was common. **Hapawai** (*Neritina vespertina*) was present in the lower stream. In the middle reach, ‘o‘opu alamo‘o (*Lentipes concolor*) and the native shrimp, ‘ōpae ‘kala‘ole (*Atyoida bisulcata*) were also present. The substrate in the lower and middle reaches of Nua‘ailua Stream was characterized by cobble and boulder with runs and pools. Water depths were between 8 and 16 inches. Water temperature ranged from 21.41° C to 21.16° C.

The upper reach substrate was characterized by cobble, boulder and bedrock. The water temperature was 18.5° C; cooler than the middle and lower reaches. Above the ditch, the habitat surveyed included runs and riffles and some “no water” sites were encountered. The substrate was made up of gravel, cobble and boulder. Depths were between 0 and 8 inches.

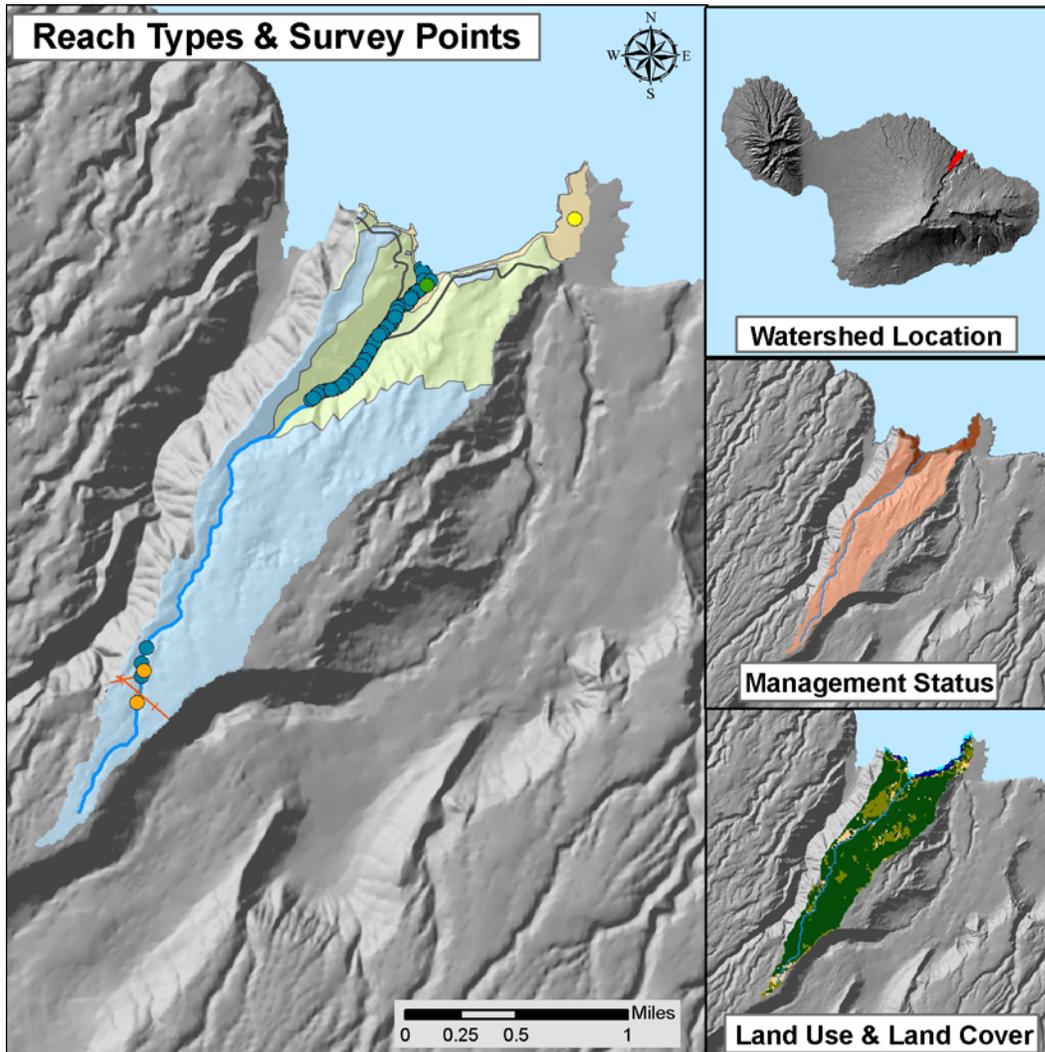
Overall, Nua‘ailua Stream has limited instream habitat due to reduced streamflow, yet a number of native species were observed. Restoration of some flow downstream would provide habitat for a range of native species downstream of the diversion. Improvement for fish passage for both up and down stream migration could substantially increase habitat for *L. concolor* and *A. bisulcata* and would further enhance the overall productivity of Nua‘ailua Stream.

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Section 2: Watershed Atlas

DAR Watershed Code: 64010

Nua‘ailua, Maui



Watershed Features

Nua‘ailua watershed occurs on the island of Maui. The Hawaiian meaning of the name is unknown. The area of the watershed is 1.6 square mi (4.2 square km), with maximum elevation of 2415 ft (736 m). The watershed's DAR cluster code is 1, meaning that the watershed is small, narrow, and steep, with little embayment. The percent of the watershed in the different land use districts is as follows: 3.1% agricultural, 96.9% conservation, 0% rural, and 0% urban.

Land Stewardship: Percentage of the land in the watershed managed or controlled by the corresponding agency or entity. Note that this is not necessarily ownership.

<u>Military</u>	<u>Federal</u>	<u>State</u>	<u>OHA</u>	<u>County</u>	<u>Nature Conservancy</u>	<u>Other Private</u>
0.0	0.0	89.5	0.0	0.0	0.0	10.5

Land Management Status: Percentage of the watershed in the categories of biodiversity protection and management created by the Hawaii GAP program.

Permanent Biodiversity <u>Protection</u>	Managed for Multiple <u>Uses</u>	Protected but <u>Unmanaged</u>	<u>Unprotected</u>
0.0	89.5	0.0	10.5

Land Use: Areas of the various categories of land use. These data are based on NOAA C-CAP remote sensing project.

	<u>Percent</u>	<u>Square mi</u>	<u>Square km</u>
High Intensity Developed	0.0	0.00	0.00
Low Intensity Developed	0.2	0.00	0.01
Cultivated	0.0	0.00	0.00
Grassland	4.0	0.06	0.16
Scrub/Shrub	14.9	0.24	0.62
Evergreen Forest	77.7	1.25	3.23
Palustrine Forested	0.0	0.00	0.00
Palustrine Scrub/Shrub	0.0	0.00	0.00
Palustrine Emergent	0.0	0.00	0.00
Estuarine Forested	0.0	0.00	0.00
Bare Land	0.1	0.00	0.01
Unconsolidated Shoreline	0.8	0.01	0.04
Water	2.2	0.04	0.09
Unclassified	0.0	0.00	0.00

Stream Features

Nua'ailua is a perennial stream. Total stream length is 3.2 mi (5.2 km). The terminal stream order is 1.

Reach Type Percentages: The percentage of the stream's channel length in each of the reach type categories.

<u>Estuary</u>	<u>Lower</u>	<u>Middle</u>	<u>Upper</u>	<u>Headwaters</u>
0.0	7.9	27.1	65.0	0.0

The following stream(s) occur in the watershed:

Nua'ailua Pi'ina'au

Biotic Sampling Effort

Biotic samples were gathered in the following year(s):

1962 1990 2002 2004 2009

Distribution of Biotic Sampling: The number of survey locations that were sampled in the various reach types.

<u>Survey type</u>	<u>Estuary</u>	<u>Lower</u>	<u>Middle</u>	<u>Upper</u>	<u>Headwaters</u>
Damselfly Surveys	0	1	0	0	0
DAR Point Quadrat	0	30	44	2	0
HDFG	0	0	0	2	0
Published Report	0	1	0	0	0

Biota Information

Species List

Native Species

- Crustaceans** *Atyoida bisulcata*
Fish *Awaous guamensis*
Eleotris sandwicensis
 Gobiid sp.
Kuhlia xenura
Lentipes concolor
Sicyopterus stimpsoni
Mollusks *Neritina granosa*
Neritina vespertina

Native Species

- Insects** *Anax junius*
Anax sp.
Megalagrion sp.

Introduced Species

- Crustaceans** *Macrobrachium lar*
Fish *Poecilia latipinna*

Introduced Species

- Insects** *Ischnura ramburi*

Species Size Data: Species size (inches) observed in DAR Point Quadrat Surveys.

<u>Scientific Name</u>	<u>Status</u>	<u>Minimum Size</u>	<u>Maximum Size</u>	<u>Average Size</u>
<i>Atyoida bisulcata</i>	Endemic	0.75	1.5	1.2
<i>Macrobrachium lar</i>	Introduced	1	4.5	2.3
<i>Eleotris sandwicensis</i>	Endemic	7	7	7.0
<i>Kuhlia xenura</i>	Endemic	0.75	1.25	1.0
<i>Lentipes concolor</i>	Endemic	0.75	2.5	1.8
<i>Sicyopterus stimpsoni</i>	Endemic	1	3	2.0
<i>Awaous guamensis</i>	Indigenous	0.675	3.5	2.0
Gobiid sp.	Indigenous	0.625	1.5	1.0
<i>Poecilia latipinna</i>	Introduced	0.75	0.75	0.8
<i>Neritina granosa</i>	Endemic	0.25	1.75	0.8
<i>Neritina vespertina</i>	Endemic	0.75	0.75	0.8

Average Density: The densities (#/square yard) for species observed in DAR Point Quadrat Surveys averaged over all sample dates in each reach type.

<u>Scientific Name</u>	<u>Status</u>	<u>Estuary</u>	<u>Lower</u>	<u>Middle</u>	<u>Upper</u>	<u>Headwaters</u>
<i>Atyoida bisulcata</i>	Endemic			0.25		
<i>Kuhlia xenura</i>	Endemic		0.5			
<i>Lentipes concolor</i>	Endemic			0.75		
<i>Neritina granosa</i>	Endemic		1.33	1.62		
<i>Sicyopterus stimpsoni</i>	Endemic		0.67	2.12		
<i>Awaous guamensis</i>	Indigenous		2.34	1.62		
Gobiid sp.	Indigenous		0.5			
<i>Macrobrachium lar</i>	Introduced		4.34	4.24		
<i>Poecilia latipinna</i>	Introduced		0.33			

Species Distributions: Presence (P) of species in different stream reaches.

<u>Scientific Name</u>	<u>Status</u>	<u>Estuary</u>	<u>Lower</u>	<u>Middle</u>	<u>Upper</u>	<u>Headwaters</u>
<i>Atyoida bisulcata</i>	Endemic			P	P	
<i>Eleotris sandwicensis</i>	Endemic		P			
<i>Kuhlia xenura</i>	Endemic		P			
<i>Lentipes concolor</i>	Endemic			P		
<i>Sicyopterus stimpsoni</i>	Endemic		P	P		
<i>Megalagrion</i> sp.	Endemic				P	
<i>Neritina granosa</i>	Endemic		P	P		
<i>Neritina vespertina</i>	Endemic		P			
<i>Awaous guamensis</i>	Indigenous		P	P		
Gobiid sp.	Indigenous		P			
<i>Anax junius</i>	Indigenous				P	
<i>Anax</i> sp.	Indigenous				P	
<i>Macrobrachium lar</i>	Introduced		P	P		
<i>Poecilia latipinna</i>	Introduced		P			
<i>Ischnura ramburi</i>	Introduced		P			

Historic Rankings

Historic Rankings: These are rankings of streams from historical studies. "Yes" means the stream was considered worthy of protection by that method. Some methods include non-biotic data in their determination. See Atlas Key for details.

Multi-Attribute Prioritization of Streams - Potential Heritage Streams (1998): No

Hawaii Stream Assessment Rank (1990): Limited

U.S. Fish and Wildlife Service High Quality Stream (1988): No

The Nature Conservancy- Priority Aquatic Sites (1985): No

National Park Service - Nationwide Rivers Inventory (1982): No

Current DAR Decision Rule Status: The following criteria are used by DAR to consider the biotic importance of streams. "Yes" means that watershed has that quality.

Native Insect Diversity
> 19 spp.

No

Native Macrofauna
Diversity > 5 spp.

Yes

Absence of Priority 1
Introduced

No

Abundance of Any
Native Species

No

Presence of Candidate
Endangered Species

No

Endangered Newcomb's
Snail Habitat

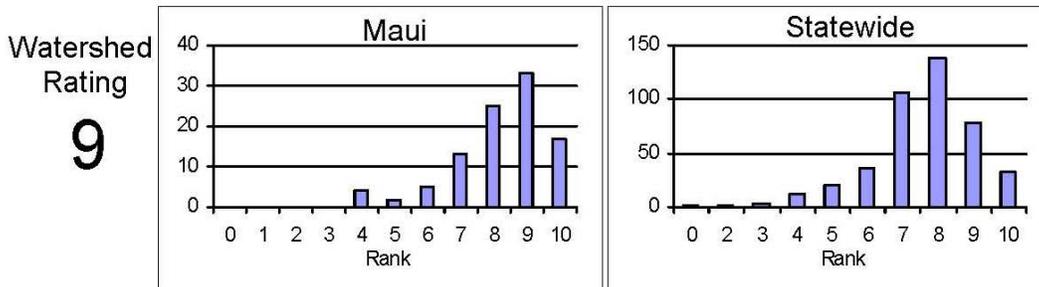
No

CURRENT WATERSHED AND STREAM RATINGS

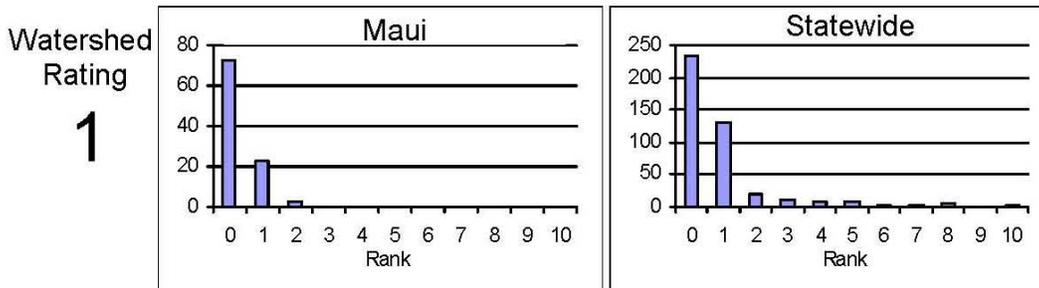
The current watershed and stream ratings are based on the data contained in the DAR Aquatic Surveys Database. The ratings provide the score for the individual watershed or stream, the distribution of ratings for that island, and the distribution of ratings statewide. This allows a better understanding of the meaning of a particular ranking and how it compares to other streams. The ratings are standardized to range from 0 to 10 (0 is lowest and 10 is highest rating) for each variable and the totals are also standardized so that the rating is not the average of each component rating. These ratings are subject to change as more data are entered into the DAR Aquatic Surveys Database and can be automatically recalculated as the data improve. In addition to the ratings, we have also provided an estimate of the confidence level of the ratings. This is called rating strength. The higher the rating strength the more likely the data and rankings represent the actual condition of the watershed, stream, and aquatic biota.

WATERSHED RATING: Nua'ailua, Maui

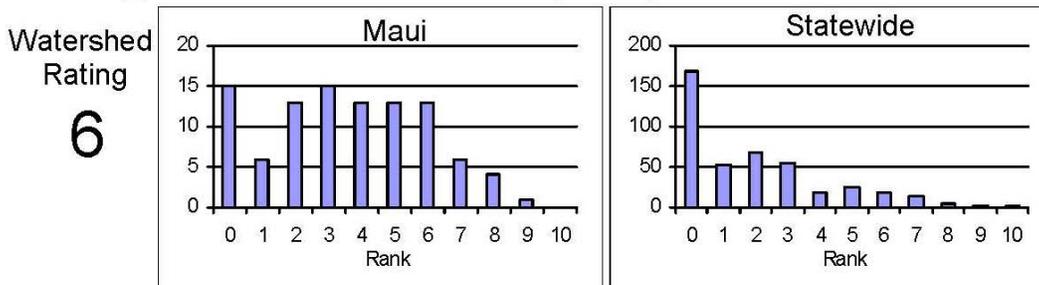
Land Cover Rating: Rating is based on a scoring system where in general forested lands score positively and developed lands score negatively.



Shallow Waters Rating: Rating is based on a combination of the extent of estuarine and shallow marine areas associated with the watershed and stream.

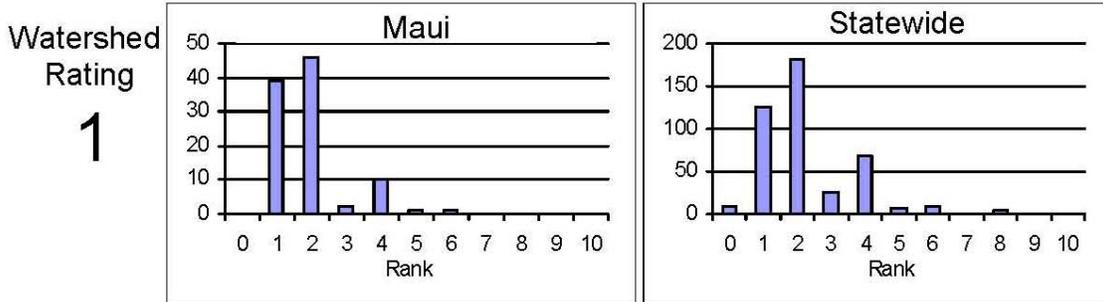


Stewardship Rating: Rating is based on a scoring system where higher levels of land and biodiversity protection within the watershed score positively.

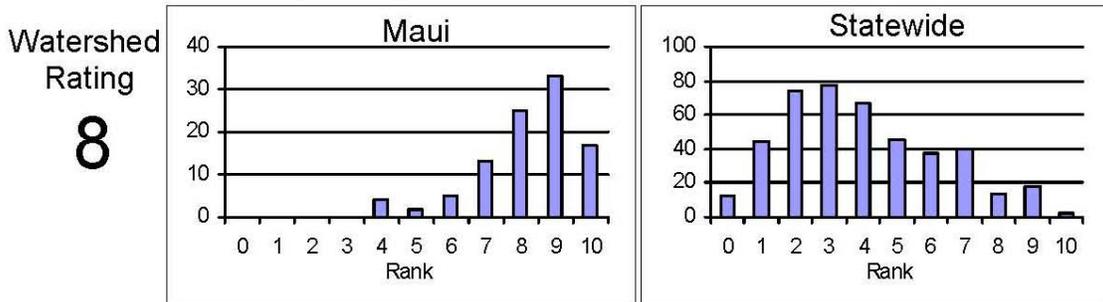


WATERSHED RATING (Cont): Nua'ailua, Maui

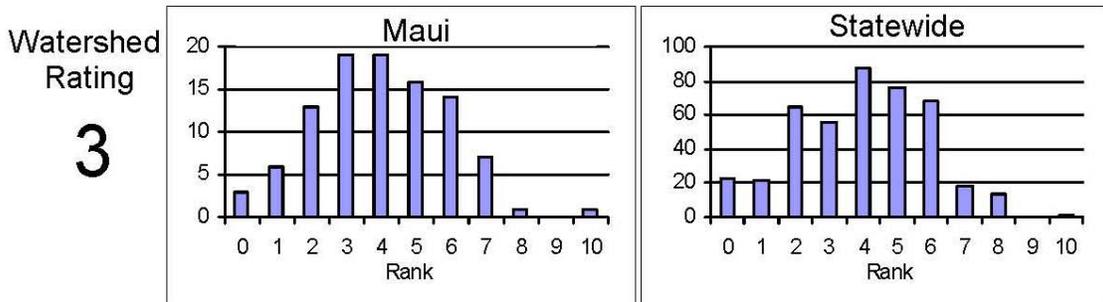
Size Rating: Rating is based on the watershed area and total stream length. Larger watersheds and streams score more positively.



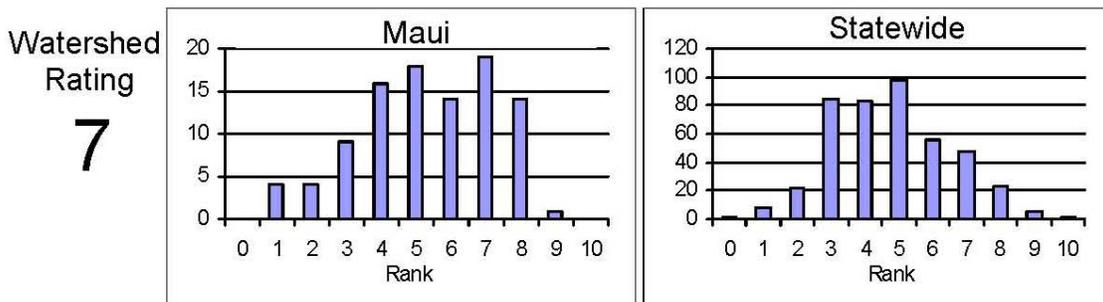
Wetness Rating: Rating is based on the average annual rainfall within the watershed. Higher rainfall totals score more positively.



Reach Diversity Rating: Rating is based on the types and amounts of different stream reaches available in the watershed. More area in different reach types score more positively.



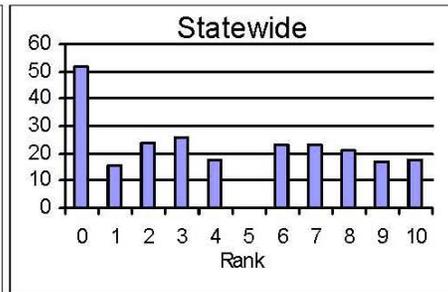
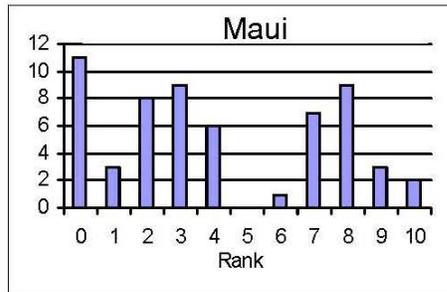
Total Watershed Rating: Rating is based on combination of Land Cover Rating, Shallow Waters Rating, Stewardship Rating, Size Rating, Wetness Rating, and Reach Diversity Rating.



BIOLOGICAL RATING: Nua'ailua, Maui

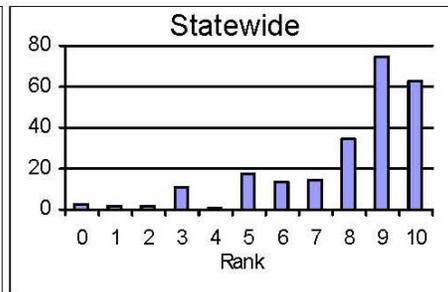
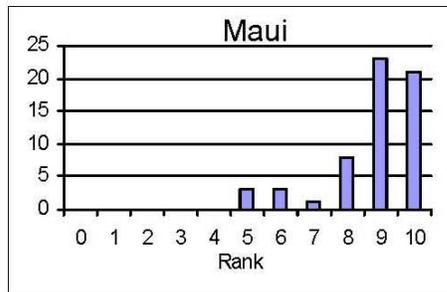
Native Species Rating: Rating is based on the number of native species observed in the watershed.

Stream Rating
8



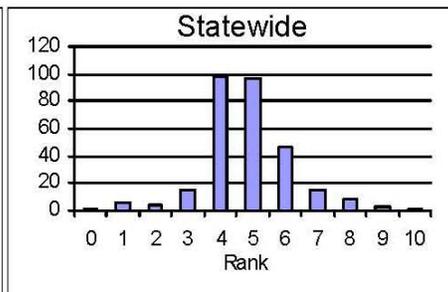
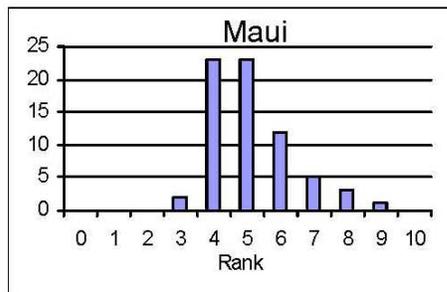
Introduced Genera Rating: Rating is based on the number of introduced genera observed in the watershed.

Stream Rating
9



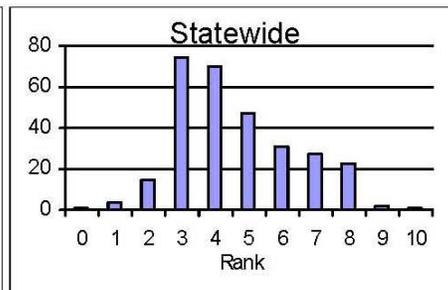
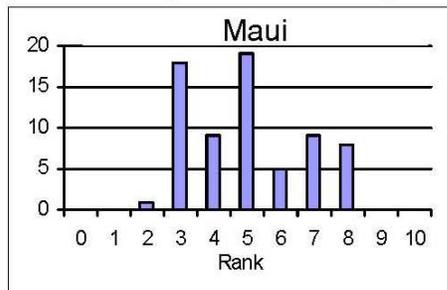
All Species' Score Rating: Rating is based on the Hawaii Stream Assessment scoring system where native species score positively and introduced species score negatively.

Stream Rating
6



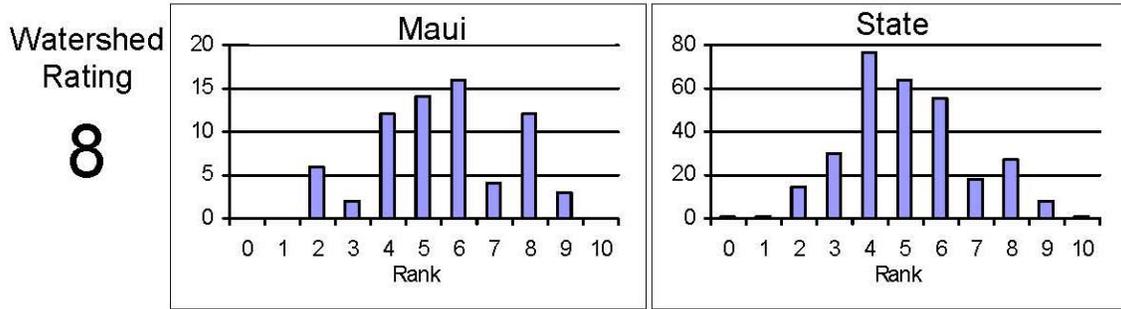
Total Biological Rating: Rating is the combination of the Native Species Rating, Introduced Genera Rating, and the All Species' Score Rating.

Stream Rating
7



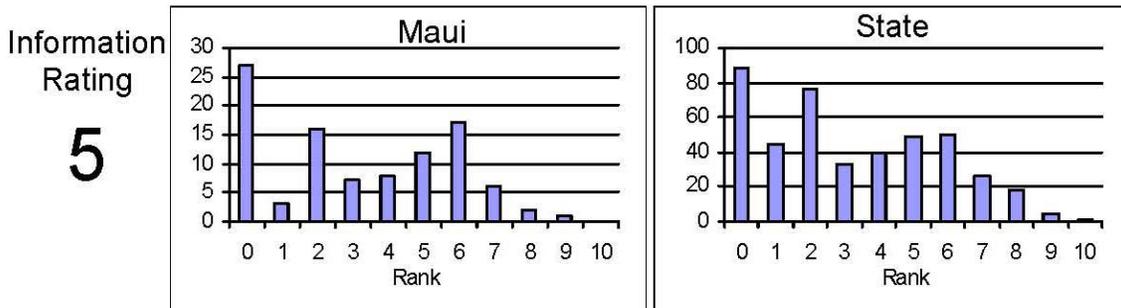
OVERALL RATING: Nua'ailua, Maui

Overall Rating: Rating is a combination of the Total Watershed Rating and the Total Biological Rating.



RATING STRENGTH: Nua'ailua, Maui

Rating Strength: Represents an estimate of the overall study effort in the stream and is a combination of the number of studies, number of different reaches surveyed, and the number of different survey types.



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- 1963. Shima, S.I. Limnological Survey for Introduction of Exotic Species of Fish.
- 2005. Gingerich, S.B. and R.H. Wolff. Effects of Surface-Water Diversions on Habitat Availability for Native Macrofauna, Northeast Maui, Hawai'i.
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- 2008. Hawai'i Division of Aquatic Resources. DAR Point Quadrat Survey Data from the DAR Aquatic Surveys Database.

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Section 3: DAR Point Quadrat Report

For Surveys from 4/30/2002 to 6/30/2009

Introduction

This is a report of the Hawai'i Division of Aquatic Resources stream surveys using the Point Quadrat Methodology. Trained biologists and technicians survey a series of randomly located points in a stream to generate an assessment of the species and habitat in the stream. The Point Quadrat Methodology is one of several techniques that could be chosen for the surveys and is used to develop a statistically comparable stream survey. This methodology is a standardized visual survey technique involving snorkeling, and it is well suited for the physical and ecological characteristics of Hawai'i streams. The small, steep, dynamic nature of Hawaiian streams with their unique aquatic species is easily observed with this methodology. The in-stream distribution by elevation, behavior, and amphidromous life cycles are easily observed using this technique.

Methods

The point quadrat methodology requires underwater observation. Sampling was conducted using a dive mask, snorkel and two-piece wet suit with hood and glove. Spiked felt-soled wading boots or Japanese spiked **tabis** are also necessary for easy climbing on the wet, algae-covered rocks. After the initial survey site is chosen all the survey sites upstream are selected randomly to prevent any bias in habitat type selection (e.g., pools and runs) and to obtain a representative sample of all habitat types in the stream. At each site, fish and invertebrate observations are recorded and data is collected on the species present, number, size, and sex. Habitat and substrate type, depth and site dimension data are also collected. Other site observations recorded at each station include GPS coordinates and the following water quality parameters using a Hydrolab Quanta: temperature (° C), salinity (PSS), dissolved oxygen (mg/L), pH, conductivity (mS/cm) and turbidity (NTU). Stream flow measurements are collected using a Marsh McBirney Flo-Mate 2000 at the beginning and ending of each survey as well as at tributaries and diversions.

The watersheds (and watershed ID), region, and island surveyed in this report are:

Nua'ailua (ID: 64010), Ke'anae, Maui

Surveys were conducted by these personnel:

Hau, Skippy
Kuamo'o, Darrell
Leonard, Jason
Nishimoto, Robert
Nishiura, Lance
Shimoda, Troy
Young, Rodney

Results

Table 3-1. The distribution of sites by reach during this survey effort.

Reach	Total number of surveys
Estuary	0
Lower	30
Middle	44
Upper	2
Headwaters	0
Unknown	0

Lower Reach

Table 3-2. Number of Habitat Types surveyed in the lower stream reach.

Reach	Total Habitats Surveyed	Plunge Pool	Cascade	Riffle	Run	Pool	Side Pool	No Water	Dirty Water	Unknown
Lower	26	1	0	0	17	7	1	0	0	0

Table 3-3. Observed Substrates (%) in point quadrat samples in the lower stream reach.

Reach	Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
Lower	5	0	1	14	29	48	4

Table 3-4. Observed Water Quality in point quadrat samples in the lower stream reach.

Reach	Temp (° C)	sCond (mS/cm)	DO (mg/L)	pH
Lower	21.413	0.066	8.053	7.298

Table 3-5. Summary of species observed in the lower reach of the watershed.

Category	Status	Scientific Name
Crustacean	Introduced	<i>Macrobrachium lar</i>
Fish	Endemic	<i>Sicyopterus stimpsoni</i>
Fish	Introduced	<i>Poecilia latipinna</i>
Fish	Endemic	<i>Kuhlia xenura</i>
Fish	Indigenous	Gobiid sp.
Fish	Endemic	<i>Eleotris sandwicensis</i>

Fish	Indigenous	<i>Awaous guamensis</i>
Snail	Endemic	<i>Neritina vespertina</i>
Snail	Endemic	<i>Neritina granosa</i>

Table 3-6. Average Density and Total number of animals observed in the lower stream reach. Density values are calculated only for random sites, not non-random or outside sites, greater than 6 by 6 inches. Density values are in number of animals per square yard.

<u>Category</u>	<u>Status</u>	<u>Scientific Name</u>	<u>Reach</u>	<u>Avg. Density</u>	<u>Total # observed</u>
Crustaceans	Introduced	<i>Macrobrachium lar</i>	Lower	3.84	27
Fish	Endemic	<i>Sicyopterus stimpsoni</i>	Lower	0.71	5
Fish	Introduced	<i>Poecilia latipinna</i>	Lower	0.28	2
Fish	Endemic	<i>Kuhlia xenura</i>	Lower	0.43	3
Fish	Indigenous	Gobiid sp.	Lower	0.43	3
Fish	Indigenous	<i>Awaous guamensis</i>	Lower	2.28	16
Snails	Endemic	<i>Neritina vespertina</i>	Lower	0.14	1
Snails	Endemic	<i>Neritina granosa</i>	Lower	1.14	8

Middle Reach

Table 3-7. Number of Habitat Types surveyed in the middle stream reach.

Reach	Total Habitats Surveyed	Plunge Pool	Cascade	Riffle	Run	Pool	Side Pool	No Water	Dirty Water	Unknown
Middle	43	1	1	3	24	7	6	1	0	0

Table 3-8. Observed Substrates (%) in point quadrat samples in the middle stream reach.

Reach	Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
Middle	7	0	1	16	30	42	5

Table 3-9. Observed Water Quality in point quadrat samples in the middle stream reach.

Reach	Temp (° C)	sCond (mS/cm)	DO (mg/L)	pH
Middle	21.165	0.059	8.197	7.141

Table 3-10. Summary of species observed in the middle reach of the watershed.

<u>Category</u>	<u>Status</u>	<u>Scientific Name</u>
Crustacean	Introduced	<i>Macrobrachium lar</i>
Crustacean	Endemic	<i>Atyoida bisulcata</i>
Fish	Endemic	<i>Sicyopterus stimpsoni</i>
Fish	Endemic	<i>Lentipes concolor</i>
Fish	Indigenous	<i>Awaous guamensis</i>
Snail	Endemic	<i>Neritina granosa</i>

Table 3-11. Average Density and Total number of animals observed in the middle stream reach. Density values are calculated only for random sites, not non-random or outside sites, greater than 6 by 6 inches. Density values are in number of animals per square yard.

<u>Category</u>	<u>Status</u>	<u>Scientific Name</u>	<u>Reach</u>	<u>Avg. Density</u>	<u>Total # observed</u>
Crustaceans	Introduced	<i>Macrobrachium lar</i>	Middle	5.02	56
Crustaceans	Endemic	<i>Atyoida bisulcata</i>	Middle	0.18	2
Fish	Endemic	<i>Sicyopterus stimpsoni</i>	Middle	0.99	11
Fish	Endemic	<i>Lentipes concolor</i>	Middle	0.9	10
Fish	Indigenous	<i>Awaous guamensis</i>	Middle	1.7	19
Snails	Endemic	<i>Neritina granosa</i>	Middle	1.88	21

Upper Reach

Table 3-12. Number of Habitat Types surveyed in the upper stream reach.

Reach	Total Habitats Surveyed	Plunge Pool	Cascade	Riffle	Run	Pool	Side Pool	No Water	Dirty Water	Unknown
Upper	2	0	0	1	0	0	0	1	0	0

Table 3-13. Observed Substrates (%) in point quadrat samples in the upper stream reach.

Reach	Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
Upper	10	0	0	10	25	25	30

Table 3-14. Observed Water Quality in point quadrat samples in the upper stream reach.

Reach	Temp (° C)	sCond (mS/cm)	DO (mg/L)	pH
Upper	18.52	0.047	8.54	7.06

Table 3-15. Flow data taken during point quadrat in the lower stream reach.

Latitude	Longitude	Total CFS	MGD
20.85837	-156.15697	0.61	0.39

Table 3-16. Flow data taken during point quadrat in the middle stream reach.

Latitude	Longitude	Total CFS	MGD
20.85490	-156.16063	0.29	0.19

Table 3-17. Flow data taken during point quadrat in the upper stream reach.

Latitude	Longitude	Total CFS	MGD
20.83374	-156.17751	0.23	0.15
20.83290	-156.17752	0.05	0.03

Table 3-18. Location of the diversion found within the upper reach and the corresponding tributary.

Latitude	Longitude	Tributary
20.83374	-156.17751	64010001

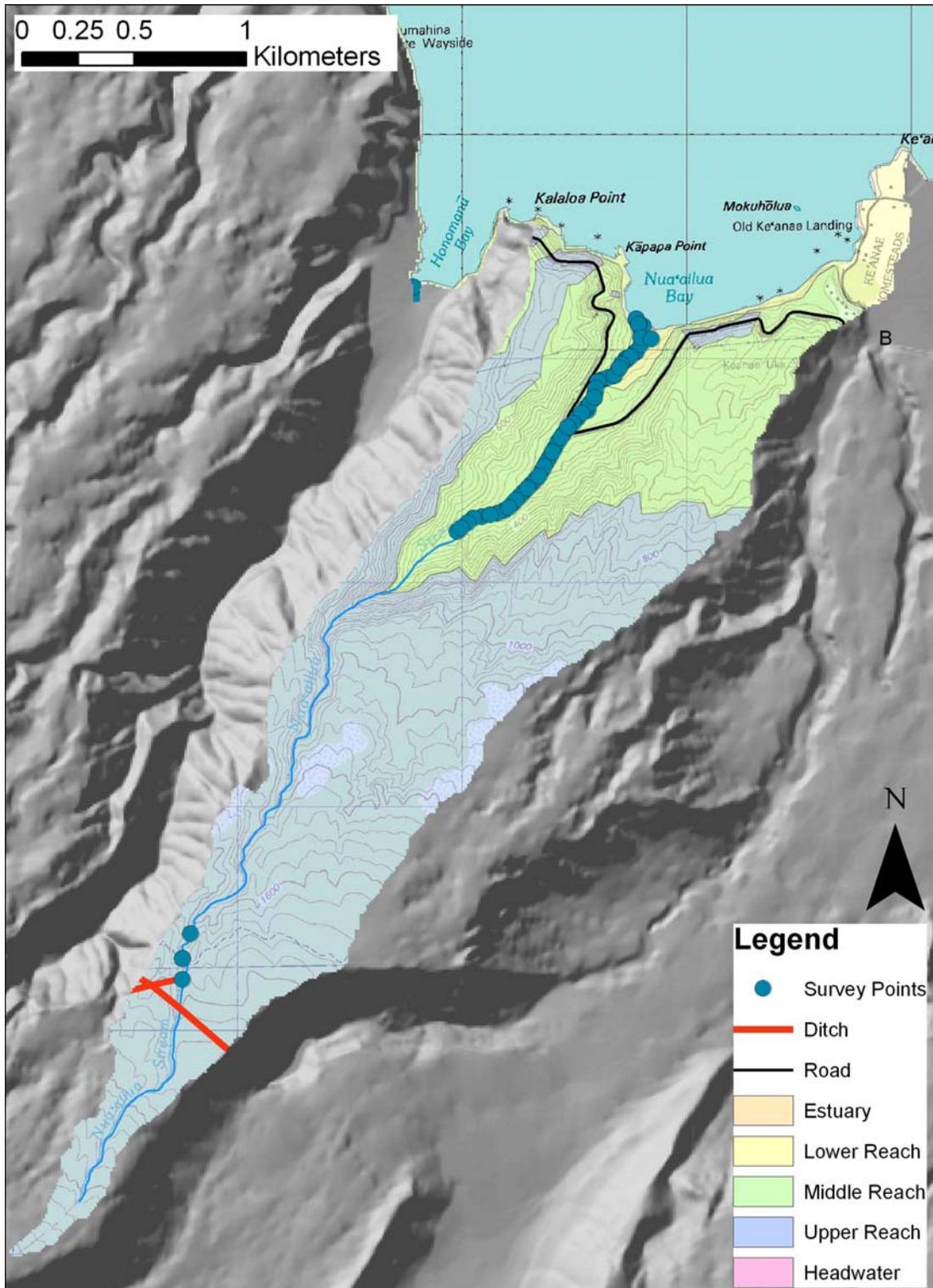


Figure 3-1. Locations of point quadrat surveys conducted in Nua'ailua Stream.

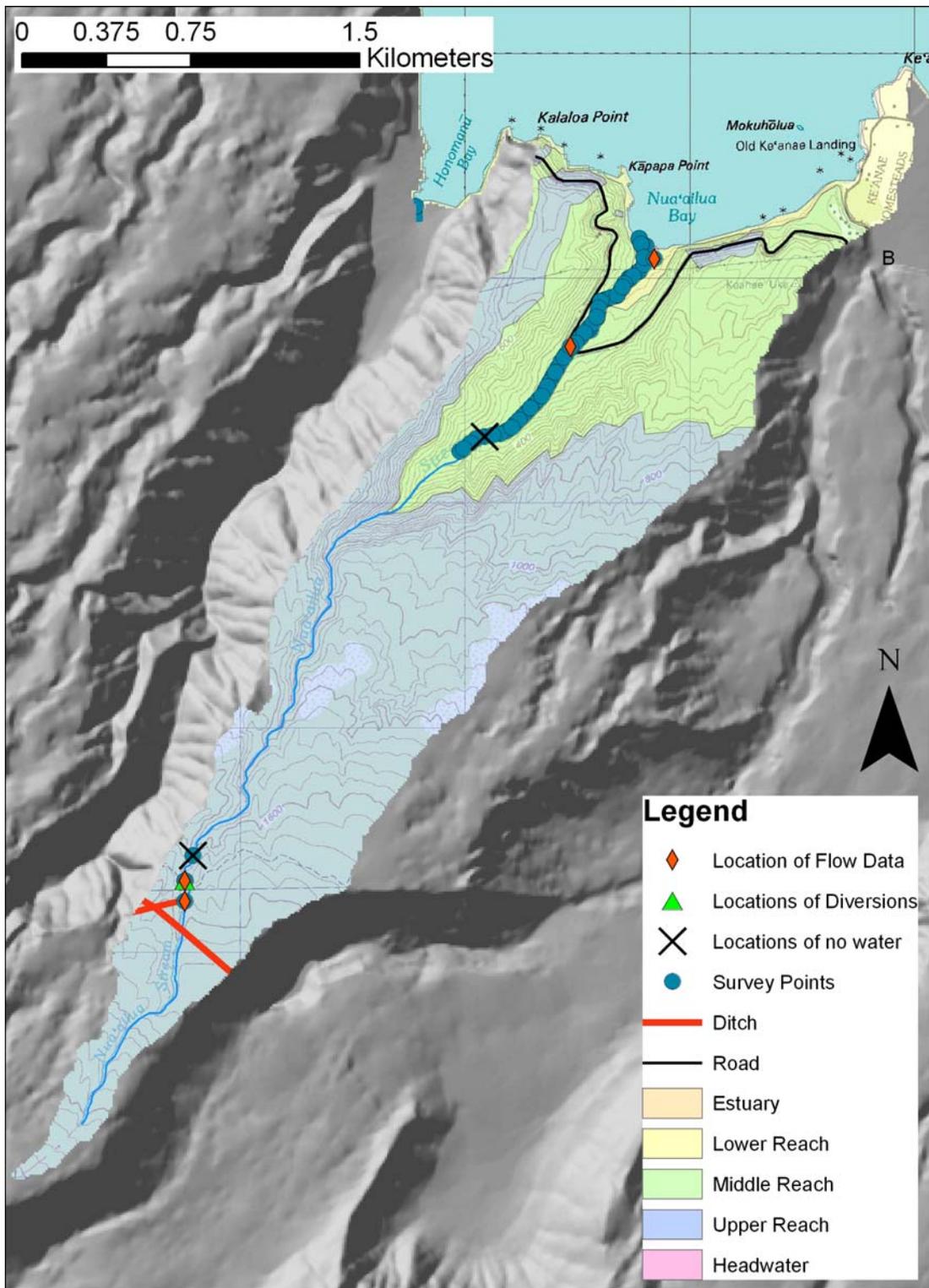


Figure 3-2. Locations of diversion, flow data and no flow conditions found in Nua'ailua Stream.

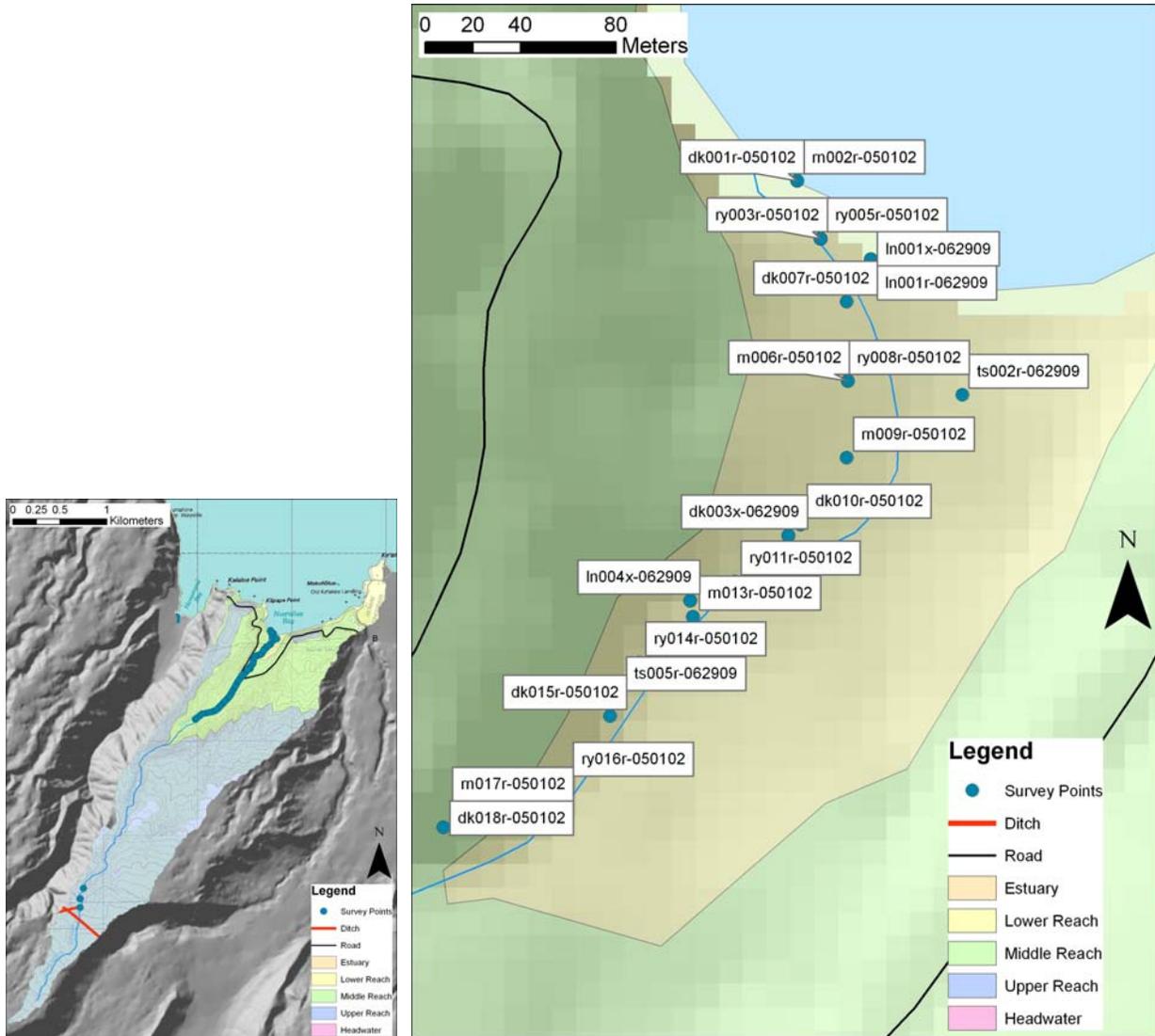


Figure 3-3. Point quadrat survey locations in the lower reach of Nua‘ailua Stream.

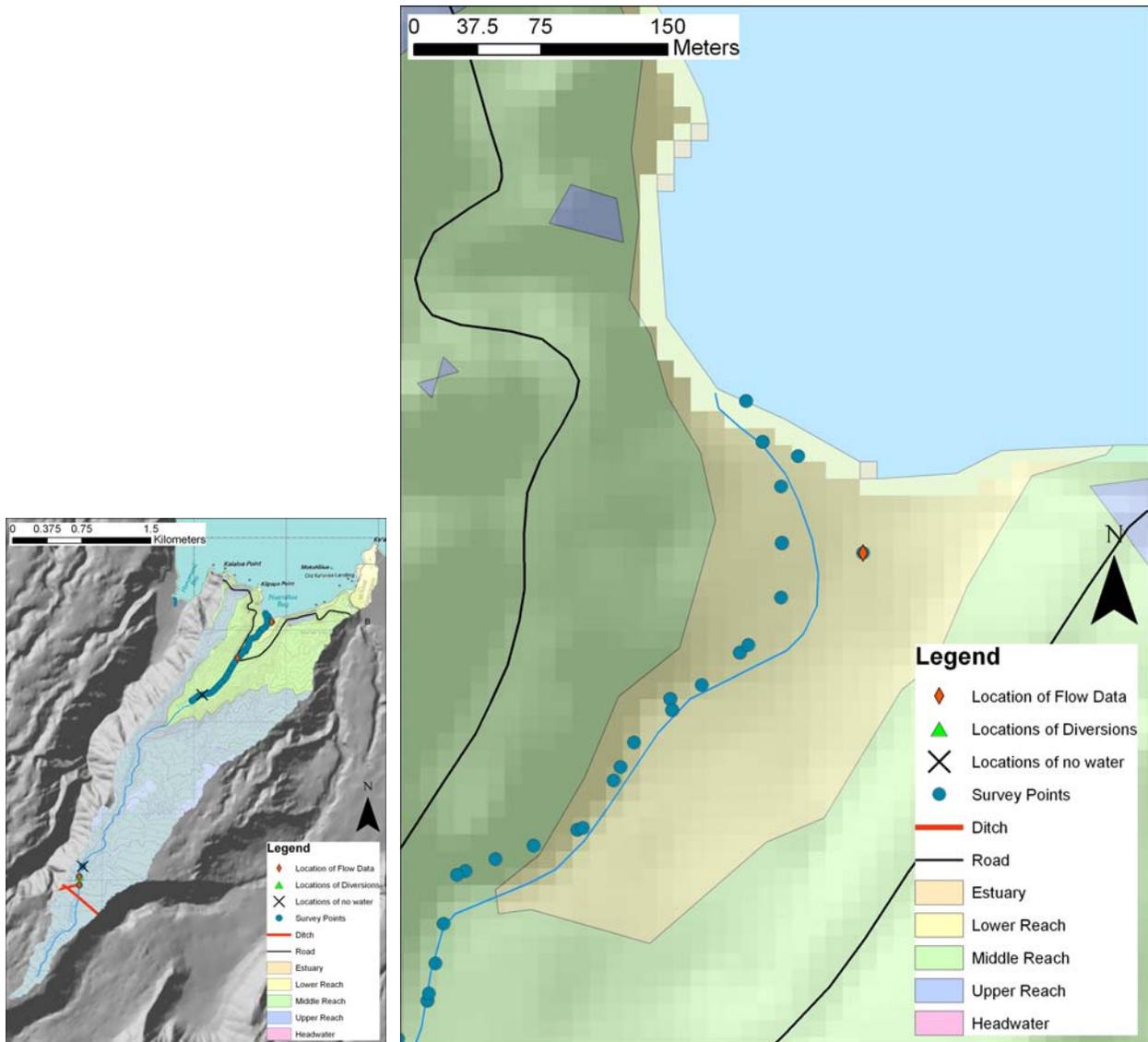


Figure 3-4. Locations of diversion, flow data and no water conditions found in the lower reach of Nua‘ailua Stream.

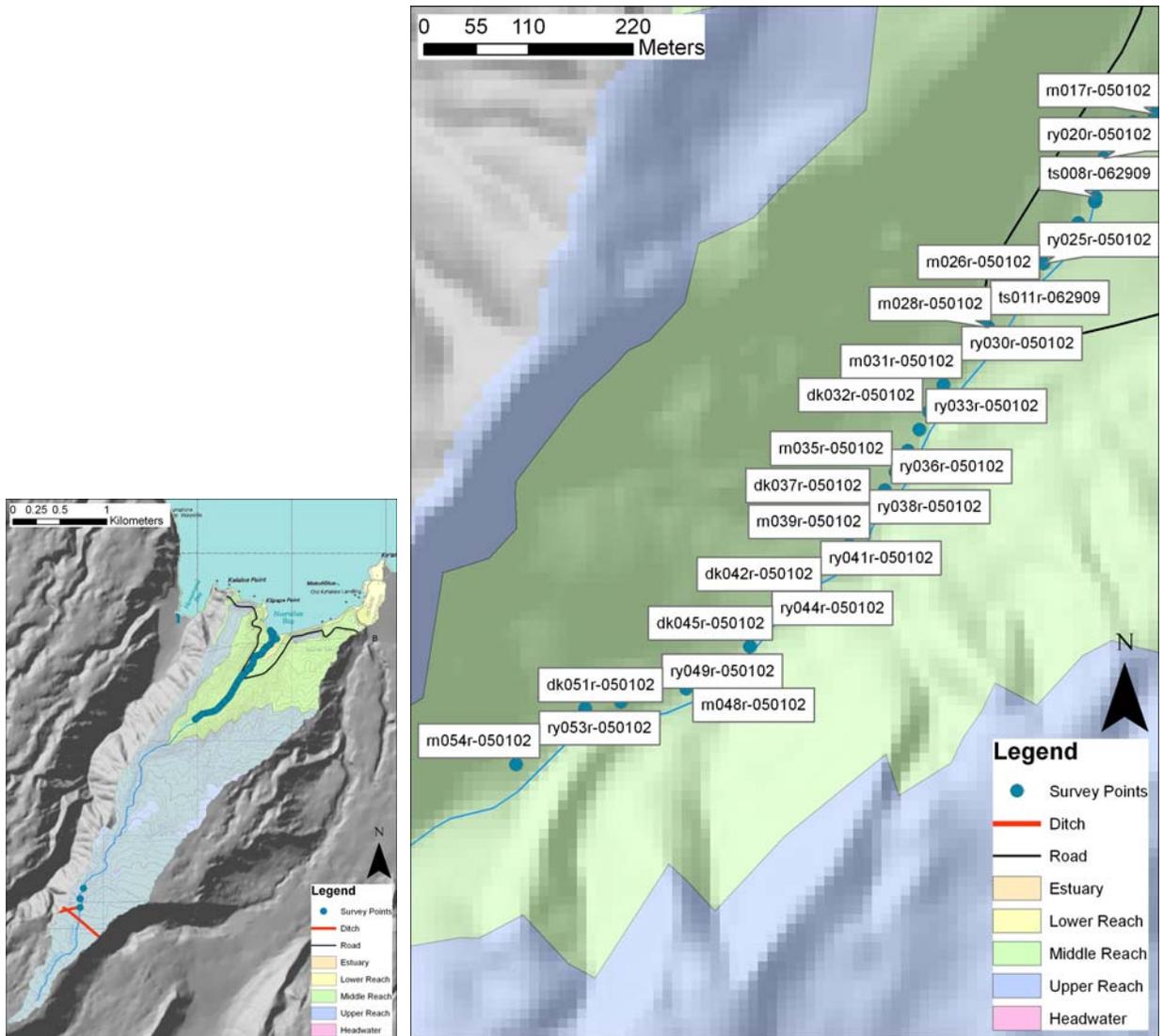


Figure 3-5. Point quadrat survey locations in the middle reach of Nua'ailua Stream.

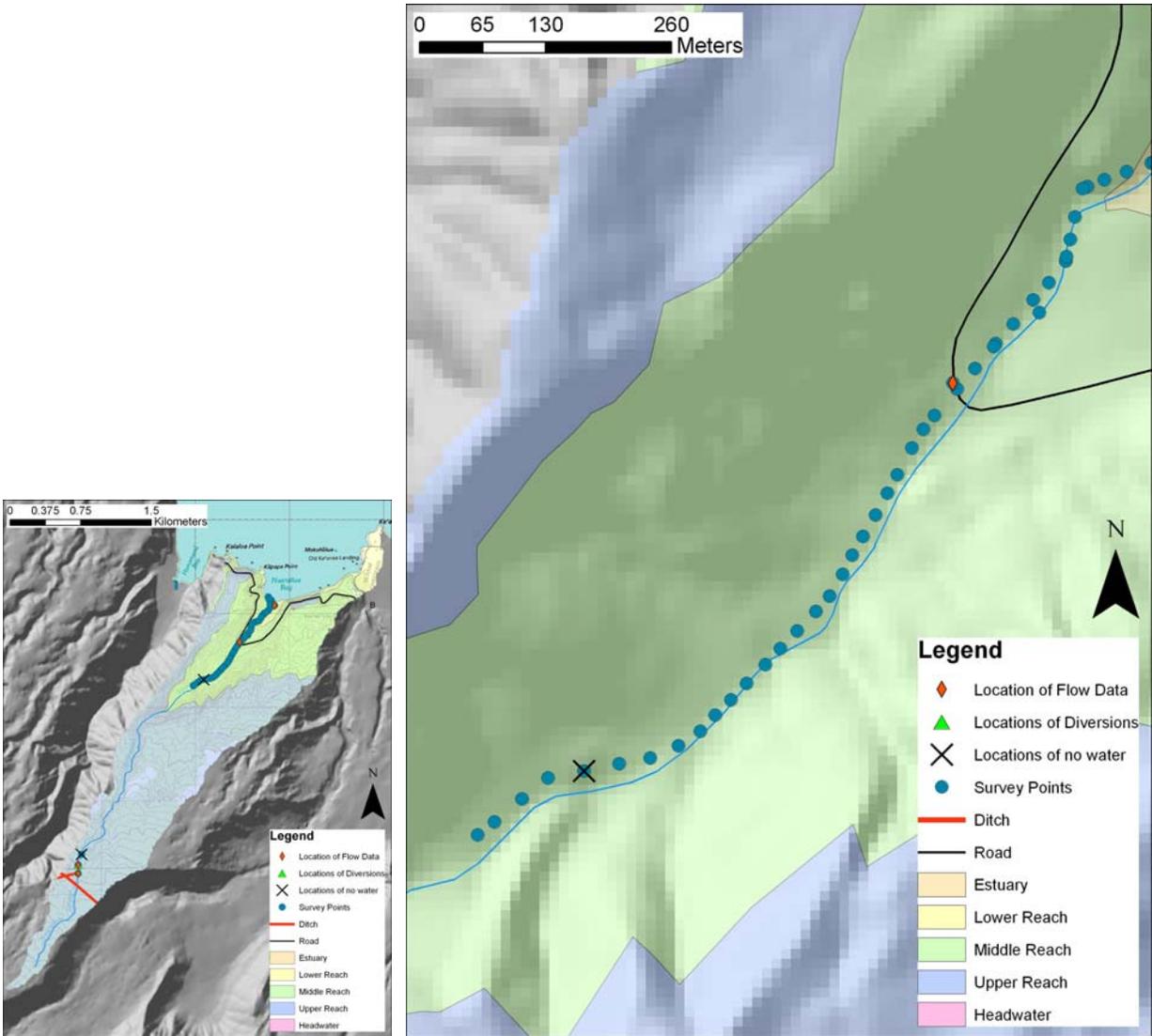


Figure 3-6. Locations of diversion, flow data and no water conditions found in the middle reach of Nua'ailua Stream.

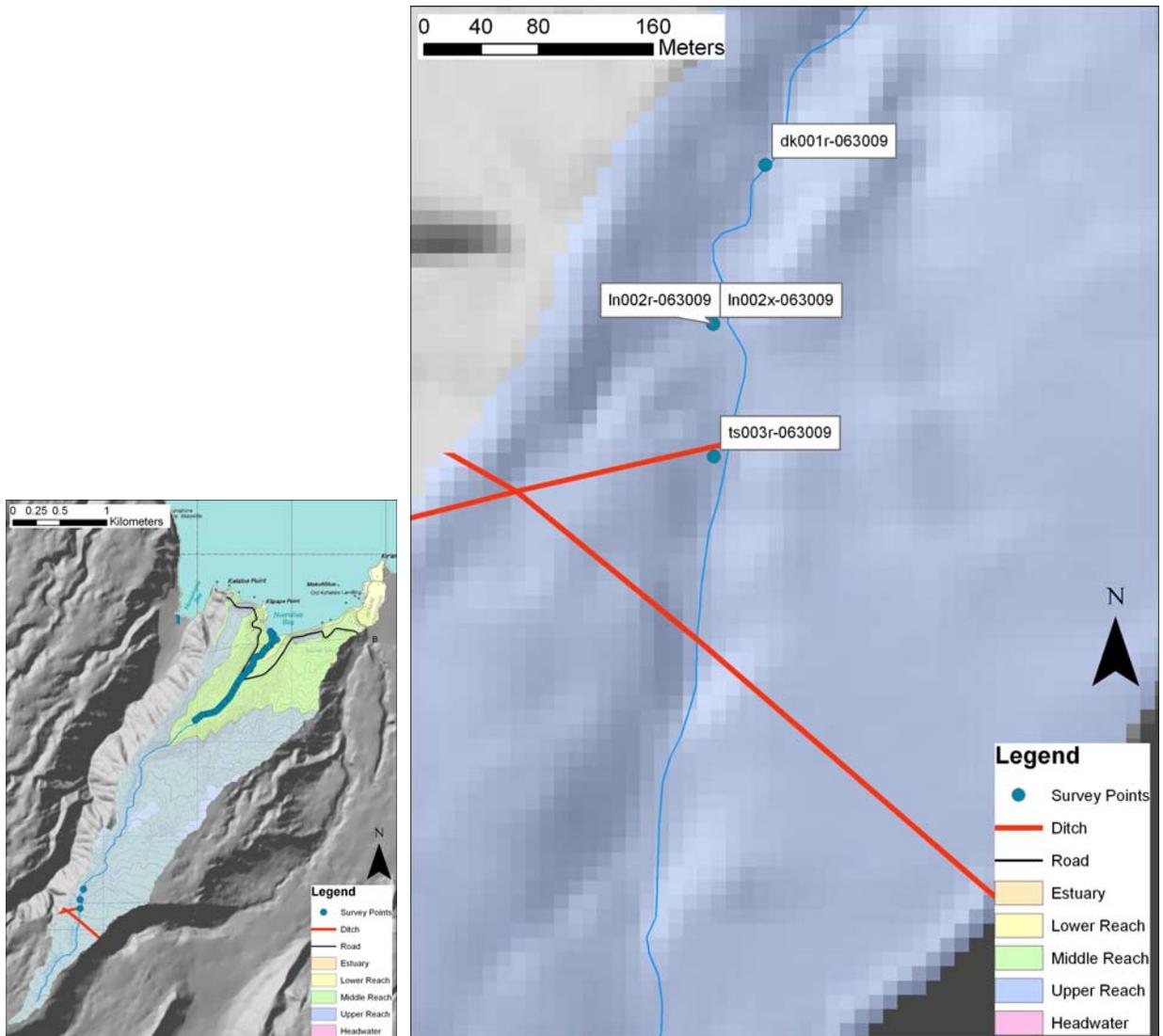


Figure 3-7. Point quadrat survey locations in the upper reach of Nua'ailua Stream.

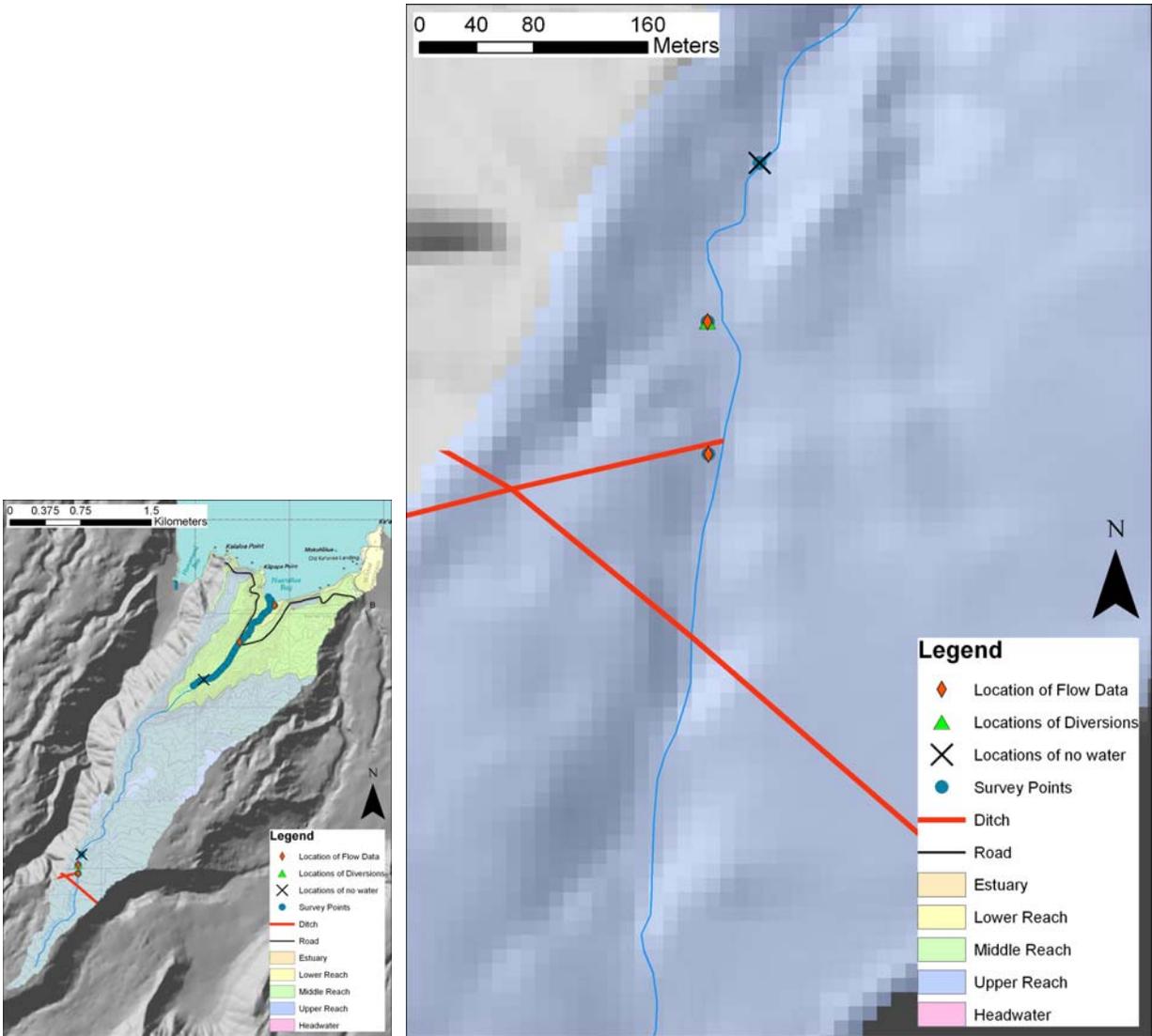


Figure 3-8. Locations of diversion, flow data and no water conditions found in the upper reach of Nua'ailua Stream.

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Section 4: DAR Estuary Survey Report

For Surveys on 6/29/2009

Introduction

This is a report of the Hawaii Division of Aquatic Resources estuary survey conducted in Nua'ailua Watershed, Maui. The main focus of the survey was to document physical conditions and animal species present in the estuary. Trained biologists and technicians sampled a series of randomly located points in the estuary to generate an assessment of species, habitat, and ecological connectivity to stream and coastal habitats. The estuary survey was conducted in conjunction with DAR point-quadrat stream surveys conducted in Nua'ailua Stream to investigate the effect of stream conditions on the native biota in the stream and estuarine habitat of Nua'ailua watershed. The data in this report reveals the potential adverse effects of stream alterations to biological resources in the stream and estuary, which bears significant ecological and cultural value. It also provides further information to determine instream flow standards and overall management of streams in Nua'ailua watershed.

Materials and Methods

Sampling was conducted using one cast net, 8 ft in length and ¼ in mesh size. Each random throw was considered a single survey site. The initial survey site was chosen non-randomly at the furthest extent of the estuary along the shoreline, which was determined by salinity level. Any salinity reading below 35‰ was considered estuarine conditions. The locations of random survey sites thereafter were determined by a random number system, which determined the approximate walking distance along the shoreline to the next survey site from the previous survey site. Fish and invertebrates captured in the net were separated, measured and recorded. All species captured were identified, measured and recorded in millimeters. Fish were measured by fork-length while invertebrates were measured by carapace length or total length depending on the classification of the specimen. All fish and invertebrates were measured manually with measuring boards. The following water quality parameters were measured and recorded at each station using a Hydrolab Quanta: temperature (° C), salinity (PSS), dissolved oxygen (mg/L), pH, conductivity (mS/cm) and turbidity (NTU). Other observations recorded were GPS coordinates, method of capture (i.e., random/non-random; cast net/scoop net), estuary status, estuary type, reach, habitat type, substrate composition (%), cloud cover (%), tide stage (ft) and depth (cm). All introduced species and mortally wounded specimens were kept, while all native species were released back into the estuary. Any unidentifiable specimens were kept and preserved in 5% formalin for later identification. Any unusual observations were also documented. This process was repeated along the shoreline until the extent of the estuary was surveyed, which was determined by a recorded salinity level equal to or greater than 35‰. Sampling also ceased if physical barriers that restricted continued surveying were reached (i.e., cliffs, hazardous terrain or high surf).

The Estuary Sampling Site, Nua'ailua, is located in the region of Ke'anae, Maui. The watershed (and watershed ID), region, and island surveyed in this report

Nua'ailua (ID: 64010), Ke'anae, Maui

Surveys were completed by these DAR staff:

- Sakihara, Troy
- Shindo, Timothy
- Hau, Skippy

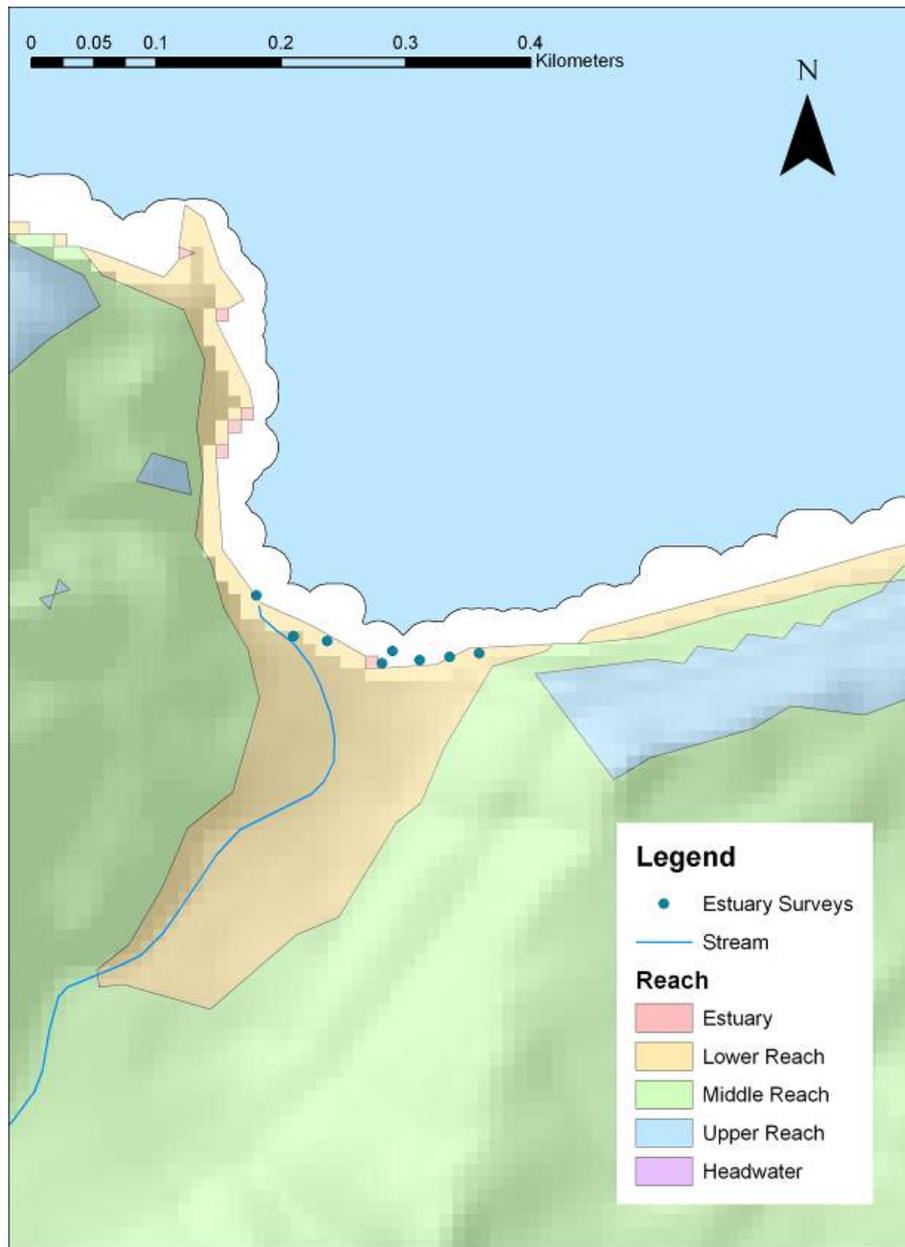


Figure 4-1: Location of estuary surveys conducted in Nua'ailua.

Results

Table 4-1. Summary of estuary classification and habitat description in Nua‘ailua.

Location	Location ID	Estuary Status	Estuary Type	Reach	Habitat Type(s)
Nua‘ailua	19	Natural	Coastal Embayment	Lower	Boulder

Table 4-2. Summary of the observed substrate average(s) (%) in the survey stations in Nua‘ailua.

Avg Detritus	Avg Sediment	Avg Sand	Avg Gravel	Avg Cobble
2	0	0	0	20
Avg Boulder	Avg Bedrock	Avg Emergent Veg	Avg Submergent Veg	Avg Coral
78	0	0	0	0

Table 4-3. Summary of the minimum, maximum, average, and the standard deviation of the depth observed in the survey sites in Nua‘ailua.

Location	Location ID	Depth min (cm)	Depth max (cm)	Depth avg (cm)	Depth Std dev. (cm)
Nua‘ailua	19	41	91	54	16.46

Table 4-4. Summary of the minimum, maximum, average, and the standard deviation of the dissolved oxygen observed in the survey stations in Nua‘ailua.

Location	Location ID	DO min (mg/L)	DO max (mg/L)	DO avg. (mg/L)	DO Std. Dev. (mg/L)
Nua‘ailua	19	5.78	6.16	6.00	0.15

Table 4-5. Summary of the minimum, maximum, average, and the standard deviation of the pH observed in the survey stations in Nua‘ailua.

Location	Location ID	pH min	pH max	pH avg.	pH Std. Dev.
Nua‘ailua	19	8.03	8.20	8.17	0.06

Table 4-6. Summary of the minimum, maximum, average, and the standard deviation of the salinity observed in the survey stations in Nua‘ailua.

Location	Location ID	Salinity min (ppt)	Salinity max (ppt)	Salinity avg. (ppt)	Salinity Std. Dev. (ppt)
Nua‘ailua	19	31.23	32.42	31.81	0.36

Table 4-7. Summary of the minimum, maximum, average, and the standard deviation of the temperature observed in the survey stations in Nua‘ailua.

Location	Location ID	Temp min (° C)	Temp max (° C)	Temp avg. (° C)	Temp Std. Dev. (° C)
Nua‘ailua	19	24.39	24.86	24.67	0.17

Table 4-8. Summary of the minimum, maximum, average, and the standard deviation of turbidity observed in the survey stations in Nua‘ailua.

Location	Location ID	Turb min (NTU)	Turb max (NTU)	Turb avg. (NTU)	Turb Std. Dev. (NTU)
Nua‘ailua	19	0.94	2.30	0.61	0.94

Table 4-9. Summary of species observed in survey sites.

Location	Location ID	Number of Surveys	Species	Category	Status	# of animals
Nua‘ailua	19	8	<i>Iso hawaiiensis</i>	Fish	Endemic	1
			<i>Kuhlia xenura</i>	Fish	Endemic	1

Table 4-10. Summary of size. Fish in fork length and crustaceans in total length

Species	Category	# of animals	Max(mm)	Min(mm)	Avg(mm)
<i>Iso hawaiiensis</i>	Fish	1	27	27	27
<i>Kuhlia xenura</i>	Fish	1	35	35	35

Summary

Estuary Surveys were conducted in the estuary reach of Nua‘ailua. A total of 203m of shoreline was surveyed in 1 discrete section. The physical characteristics of Nua‘ailua estuary were similar to other estuaries surveyed in East Maui, which consisted of boulder terrain, white water and no flow from Nua‘ailua stream into a small coastal embayment. The mouth of Nua‘ailua Stream was closed by a cobble and boulder berm created by high surf and lack of flow from the stream. The terrain and surf conditions made it quite difficult to sample, which may explain the extremely small total sample size of N=2. Nonetheless, it was expected that the sample would have been larger and more diverse, regardless of the sampling conditions. The two species recorded were common in estuary surveys conducted in East Maui.

The stream mouth was closed by berm. More marine habitat salinity varied little between sites. Hawaiian surf fish observed again as in other estuaries in high salinity 32.1 ppt. Other fish caught was āholehole which were seen in other areas. This species found mostly in estuarine conditions.

Species observed in Nua‘ailua Estuary:

Native Species

Fish *Iso hawaiiensis*
Kuhlia xenura

Section 5: Photographs taken during stream surveys

Estuary

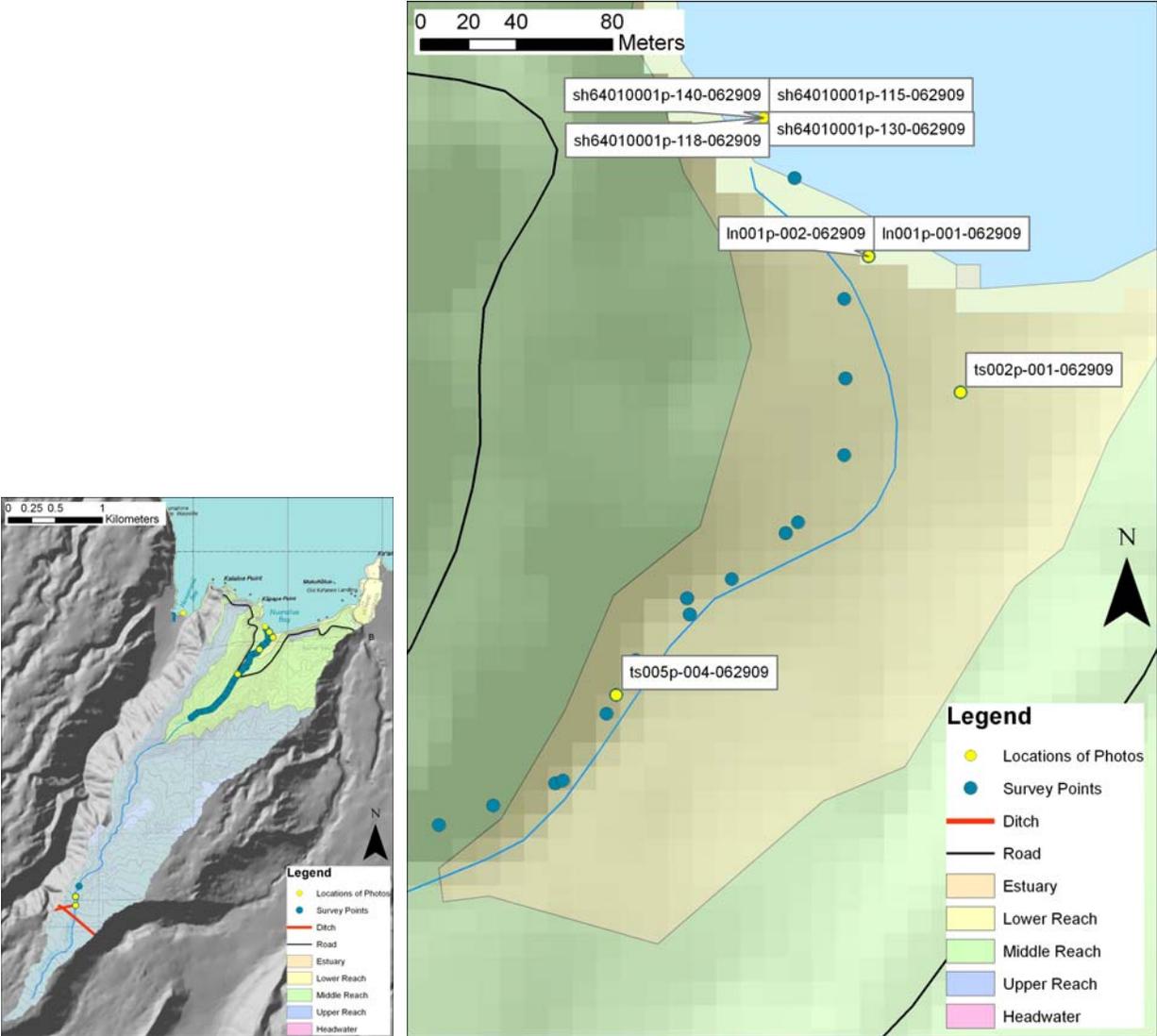


Figure 5-1. Photo locations in the estuary and lower reach of Nua'ailua Stream.



Figure 5-2. DAR surveyor conducting estuary sampling at west end of Nua'ailua Bay. Photo taken at site 8. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: sh64010001p-140-062909; Lat. (DD): 20.85942, Long. (DD): -156.15774).



Figure 5-3. DAR surveyors conducting estuary sampling in Nua'ailua Bay. Photo taken at site 5. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: sh64010001p-130-062909; Lat. (DD): 20.85942, Long. (DD): -156.15774).



Figure 5-4. DAR surveyor collecting a sample at site 1 with a cast net in Nua'ailua Bay. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: sh64010001p-118-062909; Lat. (DD): 20.85942, Long. (DD): -156.15774).



Figure 5-5. Photo of estuary in Nua'ailua Bay from site 1. View is taken westward looking towards mouth of the stream. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: sh64010001p-115-062909; Lat. (DD): 20.85942, Long. (DD): -156.15774).

Lower Reach



Figure 5-6. Photo showing upstream with water flowing under cobble from survey site 1. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: ln001p-002-062909; Surveyor: Nishiura, L.; Habitat type: Pool; SBN: ln001r-062909; Lat. (DD): 20.85889, Long. (DD): -156.15733).



Figure 5-7. Photo of survey site 1 facing the ocean. Image shows the closed mouth of Nua'ailua Stream, Maui. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: ln001p-001-062909; Surveyor: Nishiura, L.; Habitat type: Pool; SBN: ln001r-062909; Lat. (DD): 20.85889, Long. (DD): -156.15733).



Figure 5-8. Photo is taken downstream direction from survey site 2 where the flow was measured. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: ts002p-001-062909; Surveyor: Shimoda, T.; SBN: 130; Lat. (DD): 20.85837, Long. (DD): -156.15697).

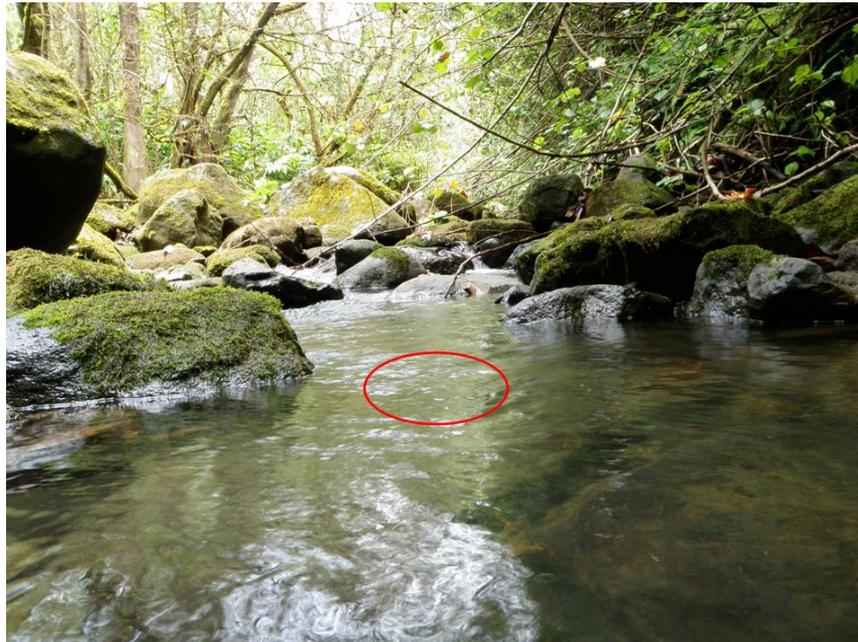


Figure 5-9. Photo was taken downstream of survey site 5 and oriented in an upstream direction. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: ts005p-004-062909; Surveyor: Shimoda, T.; Habitat type: Run; BN: ts005r-062909; Lat. (DD): 20.85725, Long. (DD): -156.15837).

Middle Reach

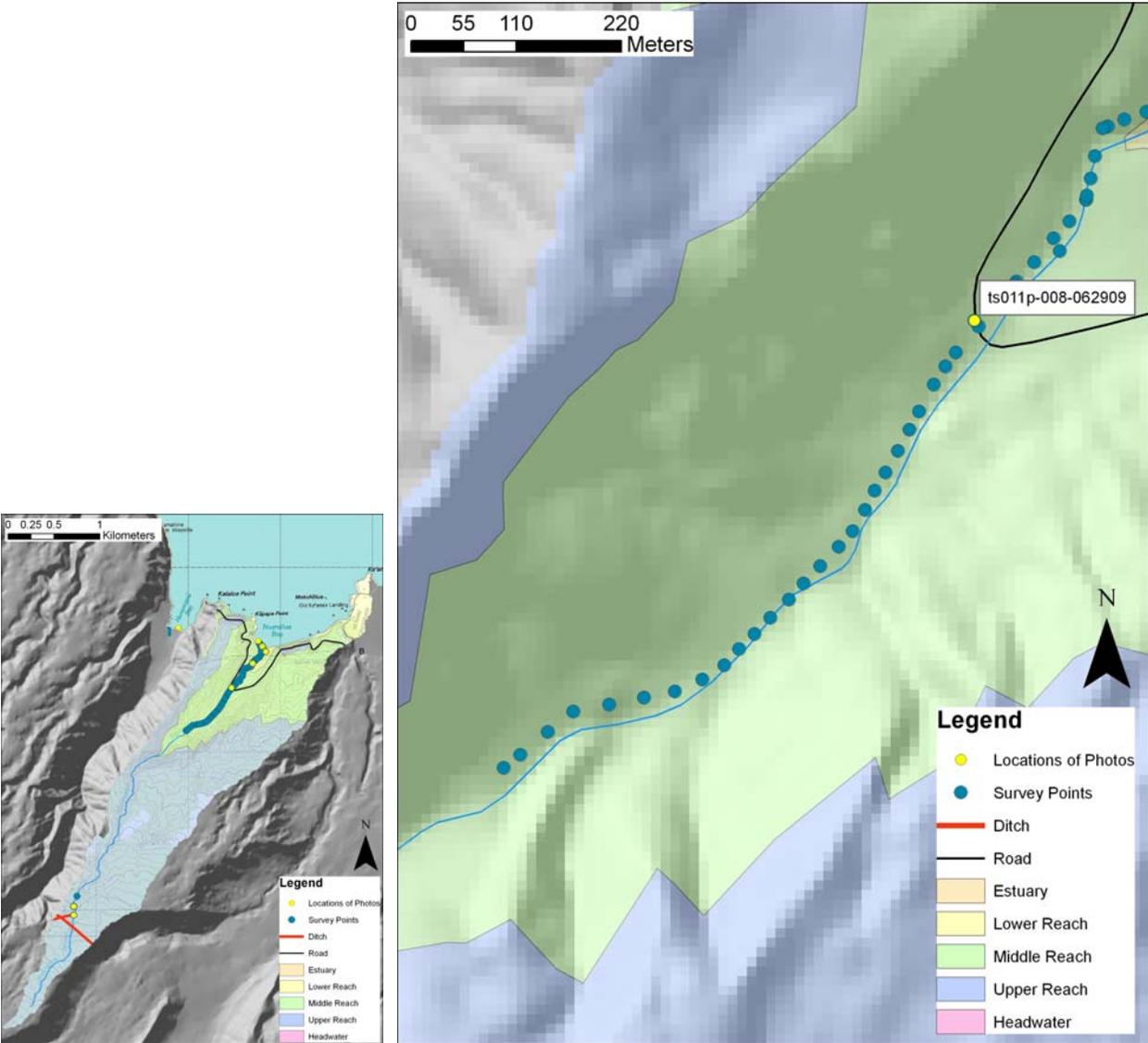


Figure 5-10. Photo locations in the middle reach of Nua'ailua Stream.



Figure 5-11. Photo was taken upstream of survey site 11 under the bridge and is at the location of the flow measurement. (6/29/2009; Tributary name: Nua'ailua (64010001); PBN: ts011p-008-062909; Surveyor: Shimoda, T.; Habitat type: Riffle; SBN: ts011r-062909; Lat. (DD): 20.85490, Long. (DD): -156.16063).

Upper Reach

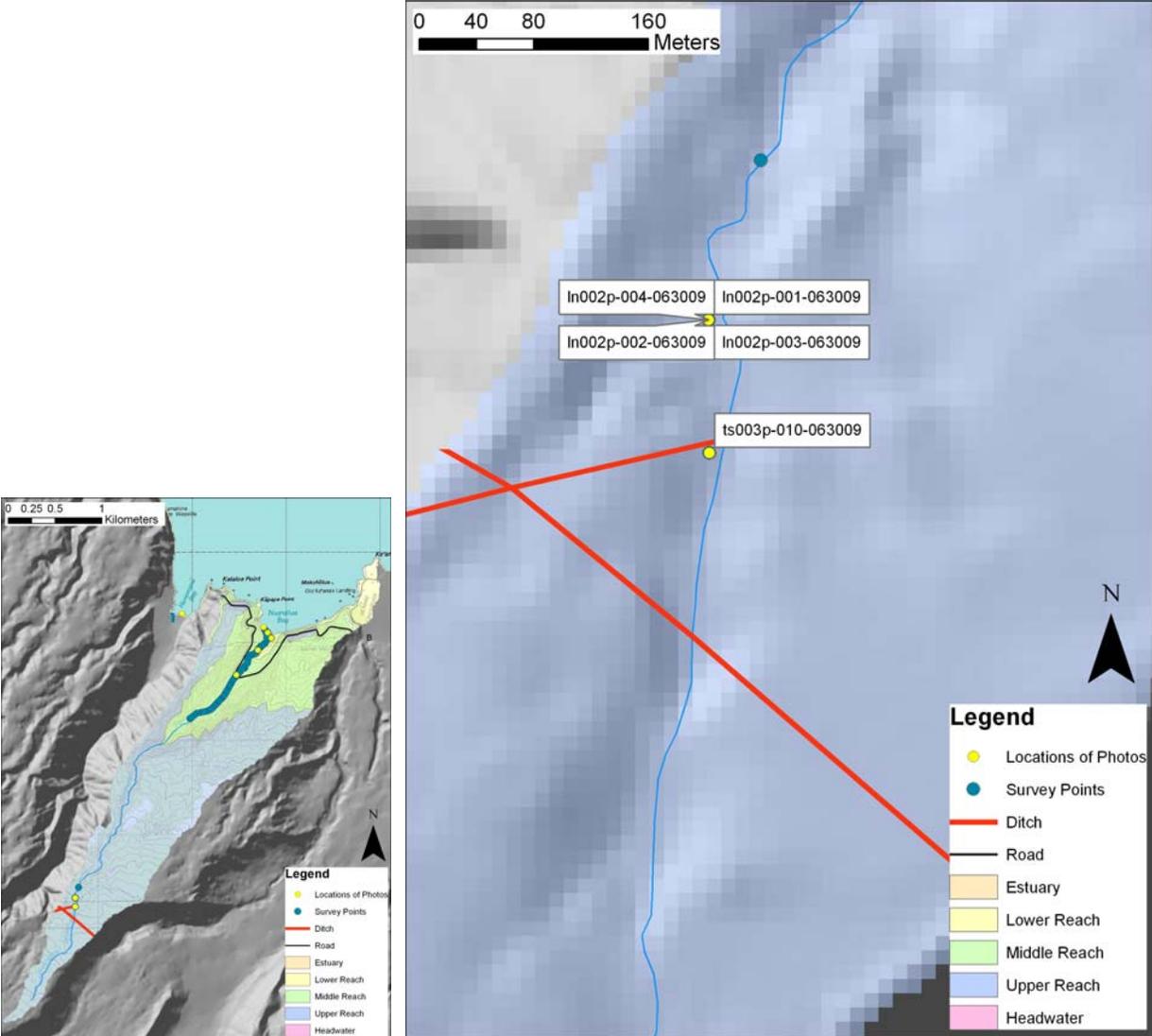


Figure 5-12. Photo locations in the upper reach of Nua'ailua Stream.



Figure 5-13. Photo is taken facing downstream toward the diversion and survey site 2. (6/30/2009; Tributary name: Nua'ailua (64010001); PBN: In002p-004-063009; Surveyor: Kuamo'o, D.; SBN: dk002d-063009; Lat. (DD): 20.83374, Long. (DD): -156.17751).



Figure 5-14. Photo is taken from the diversion and survey site 2 facing upstream. (6/30/2009; Tributary name: Nua'ailua (64010001); PBN: In002p-003-063009; Surveyor: Kuamo'o, D.; SBN: dk002d-063009; Lat. (DD): 20.83374, Long. (DD): -156.17751).



Figure 5-15. Photo of top of the diversion and showing the location of survey site 2 (red circle) and where the flow data was taken. (6/30/2009; Tributary name: Nua'ailua (64010001); PBN: ln002p-002-063009; Surveyor: Kuamo'o, D.; SBN: dk002d-063009; Lat. (DD): 20.83374, Long. (DD): -156.17751).

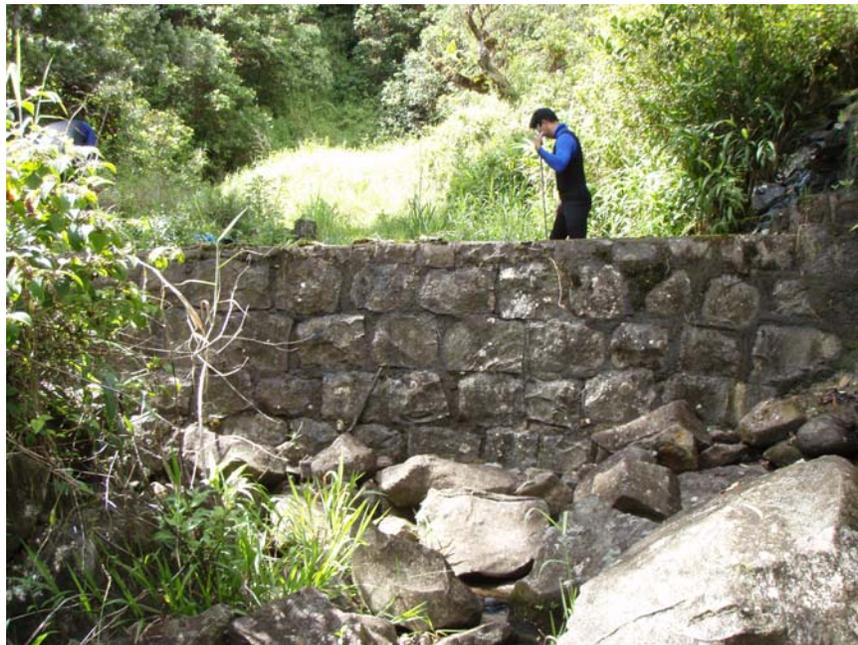


Figure 5-16. Photo was taken below the diversion and oriented upstream from survey site 1. (6/30/2009; Tributary name: Nua'ailua (64010001); PBN: ln002p-001-063009; Surveyor: Kuamo'o, D.; SBN: dk002d-063009; Lat. (DD): 20.83374, Long. (DD): -156.17751).



Figure 5-17. Photo taken downstream of survey site 3 where the flow reading was conducted upstream of the diversion. (6/30/2009; Tributary name: Nua'ailua (64010001); PBN: ts003p-010-063009; Surveyor: Shimoda, T.; SBN: 131; Lat. (DD): 20.83290, Long. (DD): -156.17752).

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- Pukui, M.K. and S.H. Elbert. 1971. Hawaiian Dictionary. University of Hawaii Press.
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Appendix: Survey Sites Latitude and Longitude

Tributary	Stream	Survey Book #	Site	Surveyor	Date	Latitude	Longitude
64010001	Nua'ailua	dk001r-050102	1	Kuamo'o, Darrell	5/1/2002	20.85919	-156.15762
64010001	Nua'ailua	rn002r-050102	2	Nishimoto, Robert	5/1/2002	20.85919	-156.15762
64010001	Nua'ailua	ry003r-050102	3	Young, Rodney	5/1/2002	20.85897	-156.15753
64010001	Nua'ailua	dk004r-050102	4	Kuamo'o, Darrell	5/1/2002	20.85897	-156.15753
64010001	Nua'ailua	ry005r-050102	5	Young, Rodney	5/1/2002	20.85897	-156.15753
64010001	Nua'ailua	rn006r-050102	6	Nishimoto, Robert	5/1/2002	20.85843	-156.15743
64010001	Nua'ailua	dk007r-050102	7	Kuamo'o, Darrell	5/1/2002	20.85873	-156.15743
64010001	Nua'ailua	ry008r-050102	8	Young, Rodney	5/1/2002	20.85843	-156.15743
64010001	Nua'ailua	rn009r-050102	9	Nishimoto, Robert	5/1/2002	20.85814	-156.15744
64010001	Nua'ailua	dk010r-050102	10	Kuamo'o, Darrell	5/1/2002	20.85789	-156.15763
64010001	Nua'ailua	ry011r-050102	11	Young, Rodney	5/1/2002	20.85768	-156.15790
64010001	Nua'ailua	dk012r-050102	12	Kuamo'o, Darrell	5/1/2002	20.85755	-156.15807
64010001	Nua'ailua	rn013r-050102	13	Nishimoto, Robert	5/1/2002	20.85755	-156.15807
64010001	Nua'ailua	ry014r-050102	14	Young, Rodney	5/1/2002	20.85738	-156.15829
64010001	Nua'ailua	dk015r-050102	15	Kuamo'o, Darrell	5/1/2002	20.85718	-156.15841
64010001	Nua'ailua	ry016r-050102	16	Young, Rodney	5/1/2002	20.85693	-156.15859
64010001	Nua'ailua	rn017r-050102	17	Nishimoto, Robert	5/1/2002	20.85684	-156.15887
64010001	Nua'ailua	dk018r-050102	18	Kuamo'o, Darrell	5/1/2002	20.85677	-156.15909
64010001	Nua'ailua	ry019r-050102	19	Young, Rodney	5/1/2002	20.85669	-156.15931
64010001	Nua'ailua	ry020r-050102	20	Young, Rodney	5/1/2002	20.85643	-156.15939
64010001	Nua'ailua	dk021r-050102	21	Kuamo'o, Darrell	5/1/2002	20.85622	-156.15944
64010001	Nua'ailua	rn022n-050102	22	Nishimoto, Robert	5/1/2002	20.85602	-156.15949
64010001	Nua'ailua	rn022r-050102	22	Nishimoto, Robert	5/1/2002	20.85602	-156.15949
64010001	Nua'ailua	ry023r-050102	23	Young, Rodney	5/1/2002	20.85582	-156.15966
64010001	Nua'ailua	dk024r-050102	24	Kuamo'o, Darrell	5/1/2002	20.85566	-156.15982

Appendix: Survey Sites Latitude and Longitude (continued)

Tributary	Stream	Survey Book #	Site	Surveyor	Date	Latitude	Longitude
64010001	Nua'ailua	ry025r-050102	25	Young, Rodney	5/1/2002	20.85544	-156.16002
64010001	Nua'ailua	rn026r-050102	26	Nishimoto, Robert	5/1/2002	20.85523	-156.16022
64010001	Nua'ailua	ry027r-050102	27	Young, Rodney	5/1/2002	20.85503	-156.16041
64010001	Nua'ailua	rn028r-050102	28	Nishimoto, Robert	5/1/2002	20.85484	-156.16059
64010001	Nua'ailua	dk029r-050102	29	Kuamo'o, Darrell	5/1/2002	20.85460	-156.16082
64010001	Nua'ailua	ry030r-050102	30	Young, Rodney	5/1/2002	20.85447	-156.16093
64010001	Nua'ailua	rn031r-050102	31	Nishimoto, Robert	5/1/2002	20.85430	-156.16105
64010001	Nua'ailua	dk032r-050102	32	Kuamo'o, Darrell	5/1/2002	20.85405	-156.16120
64010001	Nua'ailua	ry033r-050102	33	Young, Rodney	5/1/2002	20.85388	-156.16130
64010001	Nua'ailua	dk034r-050102	34	Kuamo'o, Darrell	5/1/2002	20.85368	-156.16142
64010001	Nua'ailua	rn035r-050102	35	Nishimoto, Robert	5/1/2002	20.85348	-156.16155
64010001	Nua'ailua	ry036r-050102	36	Young, Rodney	5/1/2002	20.85331	-156.16166
64010001	Nua'ailua	dk037r-050102	37	Kuamo'o, Darrell	5/1/2002	20.85313	-156.16176
64010001	Nua'ailua	ry038r-050102	38	Young, Rodney	5/1/2002	20.85293	-156.16189
64010001	Nua'ailua	rn039r-050102	39	Nishimoto, Robert	5/1/2002	20.85279	-156.16203
64010001	Nua'ailua	dk040r-050102	40	Kuamo'o, Darrell	5/1/2002	20.85261	-156.16222
64010001	Nua'ailua	ry041r-050102	41	Young, Rodney	5/1/2002	20.85245	-156.16239
64010001	Nua'ailua	dk042r-050102	42	Kuamo'o, Darrell	5/1/2002	20.85230	-156.16254
64010001	Nua'ailua	rn043r-050102	43	Nishimoto, Robert	5/1/2002	20.85213	-156.16273
64010001	Nua'ailua	ry044r-050102	44	Young, Rodney	5/1/2002	20.85198	-156.16289
64010001	Nua'ailua	dk045r-050102	45	Kuamo'o, Darrell	5/1/2002	20.85184	-156.16305
64010001	Nua'ailua	ry046r-050102	46	Young, Rodney	5/1/2002	20.85169	-156.16320
64010001	Nua'ailua	dk047r-050102	47	Kuamo'o, Darrell	5/1/2002	20.85156	-156.16342
64010001	Nua'ailua	rn048r-050102	48	Nishimoto, Robert	5/1/2002	20.85145	-156.16370
64010001	Nua'ailua	ry049r-050102	49	Young, Rodney	5/1/2002	20.85140	-156.16401
64010001	Nua'ailua	dk050r-050102	50	Kuamo'o, Darrell	5/1/2002	20.85134	-156.16436

Appendix: Survey Sites Latitude and Longitude (continued)

Tributary	Stream	Survey Book #	Site	Surveyor	Date	Latitude	Longitude
64010001	Nua'ailua	dk051r-050102	51	Kuamo'o, Darrell	5/1/2002	20.85128	-156.16472
64010001	Nua'ailua	rn052r-050102	52	Nishimoto, Robert	5/1/2002	20.85109	-156.16498
64010001	Nua'ailua	ry053r-050102	53	Young, Rodney	5/1/2002	20.85088	-156.16526
64010001	Nua'ailua	rn054r-050102	54	Nishimoto, Robert	5/1/2002	20.85076	-156.16543
64010001	Nua'ailua	ln001x-062909		Nishiura, Lance	6/29/2009	20.85889	-156.15733
64010001	Nua'ailua	dk003x-062909		Kuamo'o, Darrell	6/29/2009	20.85785	-156.15768
64010001	Nua'ailua	dk006x-062909		Kuamo'o, Darrell	6/29/2009	20.85692	-156.15862
64010001	Nua'ailua	ln004x-062909		Nishiura, Lance	6/29/2009	20.85761	-156.15808
64010001	Nua'ailua	dk001r-063009	1	Kuamo'o, Darrell	6/29/2009	20.83474	-156.17714
64010001	Nua'ailua	ln001r-062909	1	Nishiura, Lance	6/29/2009	20.85889	-156.15733
64010001	Nua'ailua	ts002r-062909	2	Shimoda, Troy	6/29/2009	20.85837	-156.15697
64010001	Nua'ailua	dk003r-062909	3	Kuamo'o, Darrell	6/29/2009	20.85785	-156.15768
64010001	Nua'ailua	ln004r-062909	4	Nishiura, Lance	6/29/2009	20.85761	-156.15808
64010001	Nua'ailua	ts005r-062909	5	Shimoda, Troy	6/29/2009	20.85725	-156.15837
64010001	Nua'ailua	dk006r-062909	6	Kuamo'o, Darrell	6/29/2009	20.85692	-156.15862
64010001	Nua'ailua	ln007r-062909	7	Nishiura, Lance	6/29/2009	20.85671	-156.15926
64010001	Nua'ailua	ts008r-062909	8	Shimoda, Troy	6/29/2009	20.85606	-156.15948
64010001	Nua'ailua	dk009r-062909	9	Kuamo'o, Darrell	6/29/2009	20.85554	-156.15976
64010001	Nua'ailua	ln010r-062909	10	Nishiura, Lance	6/29/2009	20.85526	-156.16020
64010001	Nua'ailua	ts011r-062909	11	Shimoda, Troy	6/29/2009	20.85490	-156.16063
64010001	Nua'ailua	ln002x-063009		Nishiura, Lance	6/30/2009	20.83374	-156.17751
64010001	Nua'ailua	ln002r-063009	2	Nishiura, Lance	6/30/2009	20.83374	-156.17751
64010001	Nua'ailua	ts003r-063009	3	Shimoda, Troy	6/30/2009	20.83290	-156.17752

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